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ON THE INFLUENCE

OF

VARIATIONS OF ELECTRIC TENSION

AS THE REMOTE CAUSE OF

EPIDEMIC AND OTHER DISEASES.

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ON THE INFLUENCE

OF

VARIATIONS OF ELECTRIC TENSION

AS THE REMOTE CAUSE OF

EPIDEMIC AND OTHER DISEASES.

By WILLIAM CRAIG,

LICENTIATE OF THE FACULTY OF PHYSICIANS AND SURGEONS, GLASGOW,
AND CONSULTING SURGEON TO AYR FEVER HOSPITAL.

CAUSAS MORBI REMOTAS COGNOSCERE QUÆRO.

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LONDON:
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TO

PETER MERE LATHAM, M.D.

Physician Extraordinary to the Queen,

FORMERLY PHYSICIAN TO ST. BARTHOLOMEW'S HOSPITAL,

THIS WORK

IS

RESPECTFULLY DEDICATED

FOR THE PLEASURE AND PROFIT EXPERIENCED IN THE PERUSAL OF HIS WORKS,

AND

FOR HIS KINDNESS AND COURTESY TO

THE AUTHOR

PREFACE.

It ought to be the object of every writer steadily to aim at finding out the truth, and, when this has been accomplished, to proclaim it to the world. A general assent will be given to this proposition; but the question may be asked, as has often been, What is truth? This is the object which every honest man has in view in his researches in the field of nature. It is attainable, however, only by a steep ascent; by a persevering and comprehensive effort. The Author is of opinion that the views put forth in the present treatise, are in accordance with truth and science as now known. He was, in consequence, encouraged to prosecute this inquiry, both by the approval of intelligent members of the profession, and because various writers have lately published views on the influence of electricity as a cause of disease. So far, however, as the Author has observed, they are neither so definite nor so comprehensive as those advanced in the following treatise, the subject of which has long occupied his attention. Some years ago, a communication with reference thereto was made to the *London Medical Gazette*, and ever since that time the question has been under his consideration; and from the facts which have been and are being brought to light, in various parts of the world, his convictions of the truth of the principles which he has adopted are more and more confirmed.

The subject is all but new; and the Author trusts that the want of polish in the style, or the imperfections in the arrangement of his work, will be indulgently considered. The advocating of views which are opposed to the faith made venerable by the hoar of bygone centuries, the jealousies and prejudices of long entertained opinions, will be apt to stand in the way of securing for this unpretending volume that cordial welcome which might otherwise have awaited it.

In the compilation of this work, the Author has made liberal use of the writings of contributors to our periodical literature; and has, in their own words, carried to its pages the facts which were required to illustrate the subject. He is quite aware that, in advocating a question which is comparatively new, and regarding which he puts foward some original views, there is great danger of his judgment being warped by his mind being so full of the subject, that, by looking continuously in one direction, other directions may be altogether overlooked and neglected; still, as others have been long looking in other directions, and with no satisfactory results, he considers himself justified in propounding his views; the principles which he has endeavoured to establish being, in his opinion, in accordance with sound judgment and true philosophy. He does not, however, by any means entertain the idea that the path on which he has entered is so clear as it may yet be made; but he trusts that other observers will prosecute the same inquiry, and assist in dispelling the darkness which yet hangs over this important subject. He has few facts to offer as the result of his own observation; yet facts which have been observed by others are not less valuable, since evidence by a second party cannot be looked upon with suspicion. Some of the pathological views which are given were suggested during the preparation of the work, and they probably account for the phenomena of disease, and its results, much better than the opinions generally entertained.

The subject being electricity, it might be conceived that the Author ought to have given some illustrations from his own experience with this element.

The observations, however, which could be made by any single individual in a remote island like that of Great Britain, would be totally inadequate to throw sufficient light on the subject. It requires contributions from all countries and climes to produce facts bearing on this subject. The witnessing is not the worse that it is not that of the Author; and the facts which were originally contributed, without any view of supporting this theory, are valuable notwithstanding, and suitable for appropriation.

The Author hopes that vanity has had little influence in prompting the present undertaking. He has had a sincere desire to attempt to throw light upon a subject which has been so long hidden in darkness and obscurity. The remote cause of disease is a subject of vital importance. It is at the incipient stage of a disease that most good can be done; and it will be when the initiatory operating cause is known, that means can be best adopted to avoid its effects. From the views here given of the pathology of cholera, very little hope can be entertained that a specific which will be effectual in the state of collapse will ever be found—a specific in the same sense as quinine is a specific in ague. When, however, the cause is known it is equivalent to the cure, as then the cause can be avoided; and if this were effectually done, and the earliest premonitions attended to in the predisposed, there would be few or no victims to this disease.

The Author has chosen the style of commentary, as he could, in this way, best explain the facts as they were presented. The nature of the facts rendered the classification difficult, but it is questionable if any other form than that adopted would have more clearly brought out his views.

It will strike the reader that a reiteration of the same idea is frequently made throughout the work. This could not be well avoided, as the same agency is represented as operating in the production of epidemic, as well as other diseases; and in representing its application to the various diseases brought under consideration, the same terms were necessarily applicable, and hence the reiteration.

Simplicity is the characteristic of the works of nature, and the more they are contemplated, the more does it appear that the operation of general laws produces the phenomena, both of health and disease, either in the animal or vegetable worlds.

AYR, *Feb.* 1859.

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ERRATUM.

Page 16, line 32, for *vertebræ*, read *vertebra*.

PRELIMINARY OBSERVATIONS.

There is no subject in the whole range of human concernment of so much importance as that which relates to the causation of diseases, and of those especially which occasionally ravage the various families of the human race. The inhabitants of almost every clime, without regard to colour or condition, have all suffered, each in their turn, from the inroads of pestilential disease.

The government of the despot and the legislature of the free state, have, by mandate and commission, attempted to bar out the fell agent which mows down with irresistible fury those whom susceptibility has prepared for its victims. How general the lamentation, and wailing, and woe which follow the track of this ruthless destroyer! It enters the peaceful and happy dwelling, and snatches from the heart of the quiet family circle its stay and staff, as well as the most lovely members of a lovely household. Sometimes it lays low the whole inmates of a devoted habitation, leaving nothing but ruin and desolation behind.

Till a late period it was supposed that severe pestilential disease had taken its departure from these shores, and migrated to a clime more congenial to its habits, more fitted to enable it to continue its devastations on the human race. But alas! for the folly of human calculations and anticipations, the fell destroyer again invaded our sea-girt isle, and laid waste, as well the scattered in the country and villages, as those in the larger congregations of the children of men.

Pestilence in these latter times is shorn of many of its horrors by the advance of civilization and science.

The ignorance and superstition which characterized the people of the dark ages, led to an aggravation of the evil of the pestilence itself. In that dark period the sick and the dying were forsaken by their nearest relatives and most intimate acquaintances, and were committed to the care of hirelings. One writer, in setting forth the miseries which occurred during the pestilence called the Black Death, in the fourteenth century, states, that when the evil had become universal, the hearts of all the inhabitants were closed to feelings of pity and humanity. They fled from the sick, and all that belonged to them, hoping, by these means, to save themselves; others carried their precautions still farther, and thought the surest way to escape death was by flight. They, therefore, left the city, women as well as men, abandoning their dwellings and their relations, and retiring into the country; but of these also many were carried off, most of them alone, and deserted by all the world—they themselves having set the example. Thus it was that one citizen fled from another; a neighbour from his neighbours; a relation from his relations; and, in the end, so completely had terror extinguished every kindlier feeling, that the brother forsook the brother; the sister the sister; the wife her husband; and, at last, even the parent his own offspring, and abandoned them, unvisited and unsoothed, to their fate.

Superstition and ignorance still prevail to a large extent, and these, added to the selfishness which is inherent in the nature of man, might, there is reason to fear, cause, to a certain extent, the same scenes to be repeated, were a like calamity to invade society at the present time. The more intelligent portion of the community, however, is divested of the impression, that pestilential disease is contageous, and consequently amongst them the disease would lose many of its horrors. Those unconnected with the profession and uninitiated in professional lore, especially the European population of India, are beginning to use their own powers of observation, and find that facts fail to convince them that cholera and other pestilential diseases are contageous; they seem to be in advance of many members of the profession, as these still adhere, on the most gratuitous data, to the opinion that the diseased, during epidemic invasions, communicate disease to the sound.

From the most distant period of the history of medicine to the present time, the remote cause of disease has been enshrouded in the greatest obscurity. The same views regarding the remote cause of disease that are at present entertained, were held in the days of the alchymists, when there was but a mere glimmering of science. Among the ancient Greeks, Hippocrates supposed that pestilential diseases were produced by emanations from the marshes, and, at this moment, writers in medicine hold the same opinion. Notwithstanding the lengthy strides which have been made in science and philosophy, the same antiquated notions are entertained respecting the origin of endemic and epidemic diseases. When we contrast the quick marches which the arts and sciences have made from a recent date, with the slow progress which has been made in throwing light upon this important and vital subject, it is anything but complimentary to us as men of science and philosophy. Our steamers can plough the ocean with a speed unknown to our sires, and our railways can carry crowds at the speed of the flight of a bird; and we have pressed the lightning into our service to carry messages as quickly as thought, from the one end of the world to the other. Seeing the advances which have been made in mechanical and chemical philosophy, and the progress which has been made in other branches of medicine, why should we in this, the subject of the greatest importance, be satisfied with the opinions which were entertained 2,000 years ago, especially when those views are so little supported by facts, and appeal so feebly to our reason and understanding. As a consequence of the obscurity which hangs over the primary cause of pestilential disease, the opinions of medical men are divided, as to the source of the agency which operates in producing disease. There are two classes who thus maintain different opinions respecting the cause of epidemic diseases, the one contagionist and the other non-contagionist. The one party asserts that the diseased affect the sound by the emanation from their bodies of a certain poison, as yet unknown, that enters the blood and contaminates the whole frame. The other party maintains that certain emanations from the soil, the products of the decomposition of dead animal and vegetable matter, acted on by moisture and solar heat, are the cause of epidemic diseases. As a consequence of the absence of any definite idea of the agency which operates so mischievously in producing these diseases, both parties frequently find difficulty in procuring material for the purpose of supporting their position. Outbreaks of pestilential disease frequently occur in some localities where it is impossible for the contagionists to trace its origin to contact with the diseased; and, on the other hand, the non-contagionists find that these diseases frequently take place where none of the conditions can be discovered which are required by them to be present to produce disease, where there is neither decaying vegetable nor dead animal matter. If, then, a rational idea were embraced, or, in other words, were the real cause of epidemic disease discovered, an end would be put to the contrariety of opinion on this subject of contagion.

Medical men, in considering this subject, have had their minds absorbed with pre-conceptions regarding the origin of diseases, by inheritance from former generations. It has been always supposed that an invisible, unknown, and totally inappreciable, but mischievous agent entered the blood, and produced the disease. As it was observed that these diseases, for the most part, took place in particular localities in the vicinity of marshes, on the banks of rivers, borders of lakes, &c., it was supposed that a particularly mischievous agent was generated by the decomposition of the animal and vegetable debris which is generally found in collections of stagnant water, especially in the torrid zone. The contagionist party do not hold these views, as they believe that the disease is propagated by a poison emitted from the bodies of the sick. Their minds being satisfied with the mysterious and unknown, they have not been directed to other agencies which are capable of influencing the animal frame in the most powerful manner, and of producing the very changes which are supposed to exist in the human body, whilst labouring under epidemic diseases.

It is now more than seven years since the author published a small monograph in the *London Medical Gazette*, in which views were advanced which he considered of a rational character, as he pointed out an agency powerful enough, and probable enough, to cause the changes which are found in those who are suffering from pestilential and other diseases.

To discover the cause of "the pestilence that walketh in darkness, and the destruction that wasteth at noon-day," has occupied the minds of many inquirers ever since the above declaration was made by the sacred poet; and even at this day, there is much groping in the darkness in which it is still enshrouded.

It is believed, however, by many, that some light begins to dawn on the horizon of this dark subject, and that it may yet break forth into the effulgence of day. At all events, it is not likely that an opinion, expressed in a late number of the *Lancet*, has the weight of an oracle, when it declares, "What this cause is, we know not; and we know that no one else understands it. We cannot speculate upon it; we believe it, in short, to be beyond the reach of human knowledge."

Human knowledge has made rapid strides during the last half century, and it would be folly to limit the extent to which it may yet be carried. In how many directions have science and philosophy made magnificent development in the present age? Who in the ages gone by would have believed that so many triumphant advances could have been made as have marked the track of the philosopher and the man of science during the last half of the present century? And, when it is found that the labourers in other branches of science and philosophy have, by their researches, dissipated the darkness that hung over the field of their operations, why ought the members of such a profession as that of medicine to be satisfied with the darkness which rests on a subject of so much importance as that of the causation of disease?

There is neither profit nor satisfaction in cultivating the field of conjecture, and settling down on a flimsily supported hypothesis, when there is a sufficiently adequate, and powerfully operating cause, active or latent, in every terrestrial object. This element is in the air we breathe, is bound up in the food we eat, pours down from the sun in the heavens, raises into the clouds from the land and sea forty cubic miles of water every twenty-four hours, and thunders and darts irresistably in the heavens. This is an element the power of which is manifested before our eyes in a thousand different forms, and, till now, has not with full force struck the mind of the inquiring physiologist to consider how far it acts in producing those changes in the corporeal manifestations which are found in certain places and at certain seasons.

Considerations such as these, may encourage efforts in the least hopeful direction, even on subjects that have been long obscure, and little understood; and, these efforts being continued, light may arise where it was least expected. It was with this view that the author had, in 1851, published opinions, different from those hitherto hold, as to the cause of epidemic disease; and he intends to embody in this treatise the views there stated. There is not in the whole range of medical philosophy, a field that has been so much occupied with theories and speculations as that which relates to the remote cause of *endemic and epidemic diseases.* Animalculæ in the air, emanations from the earth of every character, and numerous other gratuitous speculations—even that volcanoes have a mischievous instrumentality—have their advocates and supporters. The very circumstance of the great number and contrariety of the theories which have been promulgated on this subject, and the unanimity which has existed in the adoption of the term "miasm," which more directly signifies the action of an agent than the agent itself, indicates that the dreadful instrumentality which occasionally mows down our species with irresistible force is still unknown, and leaves room for further research, and apologises for new theories still.

CHAPTER I.

ON THE GROUNDS FOR THE CONCLUSION THAT ELECTRIC POWER AND NERVOUS POWER ARE IDENTICAL.

Electricity has been placed amongst the malevolent agents which are supposed to cause these diseases. It is only lately, however, that anything like a rational theory of the action of this agent has been entertained and advocated. In connecting electricity with the cause of epidemic disease, authors have almost uniformly referred in a vague and indefinite manner to the electricity of the air, and to that on the earth's surface, without reference to its internal elimination.

Dr. Copland, in his article on Glandular or Septic Pestilence,* observes that "the electrical conditions of the atmosphere have been supposed to be more or less influential in producing epidemics of plague and of the other two pestilences; but the particular electrical conditions have not been shown, the negative state being most frequently accused. Very probably, electricity, as it circulates through the animal economy and other objects on the earth's surface, and passes off into the atmosphere, by its varying states and its influence upon the nervous

* Dictionary of Practical Medicine, vol. iii. p. 220.

system, impairs in some cases, and increases in others, the nervous power and vital resistance of the frame, thereby rendering them more or less disposed to the invasion of infectious agents, and, as observed in respect of its influence on dead animal matter, imparting more or less of a septic tendency to the fluids and soft solids. Still the actual amount of influence of this agent on the living body is unascertained, and probably much exaggerated by many, especially by those who impute epidemics to atmospheric conditions, without admitting the efficient agency of specific infection."

In the above paragraph, Dr. Copland represents the views which have been entertained regarding the influence of electricity in producing disease. The ideas formed of the action of this agent in producing disease are vague and indefinite. One cause of the unsatisfactory notions existing in the minds of medical men about the influence of this agent in producing disease may be, that they have rested satisfied with the most partial, or even with the absence of all reliable evidence, that malaria, or an ideal infectious agent, is the cause of disease. Being formerly accustomed and content to look upon an unknown inappreciable agency as the "origo mali," they consider that by looking at electricity they are in advance of their old opinion, when they have found an active and known agent operating in every department of nature, engaged in germination, growth, and decomposition. There is still, however, a want of aim in their efforts to apply this agency. They allude merely to its presence in the air, its circulation through the animal body, without any allusion to its mode of operating in producing disease.

The author has long entertained the opinion that variations in electric tension on the various parts of the earth act prejudicially on those animals that may be placed on the portion of the earth which may be thus affected. In a letter which he sent to a medical friend in Glasgow, in March, 1841, there is the following observation:—

"You will have observed ere this that my object is to attempt to discover a cause of disease different from those usually known,—a cause, moreover, which is much left in the dark, and allowed quietly to work its deadly effects, making, unthought of, its undermining devastations. The analogy that subsists between nervous influence and electricity is now recognized by physiologists. The manner in which the nerves act on the blood, in order to select the constituent of the varied complicated secretions and corporeal supporting depositions, is analogous to what is understood by chemists as electric affinity. Hence, when we consider the resemblance of this imponderable body to nervous power, working in us so wonderfully and incessantly, we cannot withhold our conviction that the great changes which occur in the amount of this electric matter, and which are affected by the operation of meteorological causes, have a mighty effect on animal life. In consequence of the heat which is generated within us so continuously, we become positively electrified, or, in other words, we have a greater amount of electricity than the inanimate surrounding objects.

"Well, then, on the application of moisture to the surface of our bodies, such as takes place when we get drenched with rain, or ducked in a pool of water, the good conducting power of the water in a state of evaporation withdraws the electric fluid from our system, and the nervous power is thus deprived of the amount of support which it derived from its departed electric fluid. Now, provided the amount of nervous influence, and the assistance it received from this fluid, were just what was required for the individual to guide the animal machine, and nothing more, the abstraction of electric fluid which has taken place, would leave this structure unequal to its many duties.

"I am of opinion, that the source of epidemical diseases will ultimately be found to depend on the variations which take place in the state of the electric fluid. It seems to require a great effort of the nervous system to abstract from the blood the ingredients which form the complicated excretion, the urine. This seems to result from the little attraction the most of the substances composing it have for electricity, or otherwise, for what is reckoned analogous, the nervous power. Well, I would suppose that it will require a large amount of nervous power to take up from the blood the salts of the urine, and the phosphoric formations, as these have all a very feeble attraction for electric fluid, or, in other words, are bad conductors. Now, supposing the nervous power were in a weak condition, and the body in a comparatively negative state of electricity, these offensive ingredients which are contained in this excretion are not thrown off but circulated through the system,—thence, as in cholera, the vitiation of this fluid.

"This with, perhaps, a like operation on some other of the secretions, in all probability gives rise to the tar-like appearance of the blood, and its inability to perform its important offices in the animal economy."

At the time at which the above remarks were written, the author had not espoused the opinion that nervous power and electricity are identical, but viewed the latter in great measure as a mere supplementary power. Having, however, since the period above stated, studied the subject more attentively, he has come to the conclusion that, if not completely, it has been all but proven, that electricity and nervous power are identical. In the following treatise he will view them in this light, as this will afford an opportunity of entertaining rational views on the very important subject of the remote cause of disease.

In the following part of this treatise, then, the writer will state what he considers to be rational views respecting the operation of this agent on the animal economy. To be properly understood it will be necessary to carry along with us a few recollections of natural philosophy. It is a recognized fact in physics that heat and electricity are identical, and that the one is convertible into the other. It is also admitted as fact, that every atom of powderable matter is surrounded by a little atmosphere of heat, and it is through the agency of this element that attraction and cohesion between the primary constituents of bodies are maintained. It was mentioned by Mr. William Higgins, of Dublin, as far back as 1789, that "all compounds are formed by the union of exceedingly minute atoms which are surrounded by atmospheres of caloric." It is this caloric, surround-

ple and compound bodies, that
lled latent heat. The gaseous
be possessed of an immense
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depends. The vegetable bodies are
almost wholly composed of these gaseous bodies, and, of course, embody less or more of the heat which is individually possessed by their constituents. The saline and earthy constituents of these vegetable bodies also contain their portion of latent electricity.

These gaseous bodies—both in their æriform state, as in the atmosphere, and in their solid state, when in vegetable combination—are required to administer warmth to the animal structure. The decomposing process in the animal structure is analogous to that which takes place in a galvanic arrangement. In the galvanic process the electricity is evolved from the bodies under chemical operation, just as the separation of the bodies is being effected to form a new combination. The primary principles of this new body require less electricity than when in their original combination, and hence the evolution of electricity; so, also, in these vital operations, which are ever active during healthy existence, is there a continual giving off of vast volumes of electricity from the changes of the elementary principles that are continually going on; thus, during respiration, the oxygen, when separated from the nitrogen of the air, and uniting with the carbon of the blood, forming carbonic acid gas, parts with some of its latent electricity, as it retains less and requires less in forming this new combination with the carbon. In digestion, too, there is another source of animal electricity: whilst the food is being changed into the constituents of the body, the primary elements of the bodies which constitute the food, part with some of their latent electricity, when entering into these new formations with the animal tissues; the changed position of these elementary bodies causes them to require less electricity than in their original combination, and in like manner is there the liberation of electricity. There may be another source of electric fluid from the changes of the elementary principles of the blood during secretion.

It is evident that there is more truth in the electric theory of life than is generally admitted. The electricity so constantly and so liberally supplied by the various decomposing processes in the animal economy cannot be merely for the purpose of supporting animal temperature; it must have some other more important work to perform; and what more likely than to minister to the vital operations in corporeal existence? This opinion is strengthened even when we contemplate the part performed by electricity in the generation of force and motion in the inorganic portion of the material world.

It has been demonstrated by experiment, that, independently of vitality, the functions of a nerve can be performed by an electric current.

There have been exhibited in many instances, both in a limited portion of the human body and on the body as a whole, with a weak as well as a strong electric current, manifestations simulating as closely as might be those of vitality. A very striking exemplification of the powers of electricity on the human body was made by Dr. Ure, in

Glasgow University, about forty years ago, with a powerful galvanic arrangement. The following is the account given by the Dr. in his Dictionary.

"The subject of these experiments was a middle-sized, athletic, and extremely muscular man, about forty years of age. He was suspended from the gallows for nearly an hour, and made no convulsive struggle after he dropped; while a thief, executed along with him, was violently agitated for a considerable time. He was brought to the anatomical theatre of our University in about ten minutes after he was cut down. His face had a perfectly natural aspect, being neither livid nor tumified, and there was no dislocation of his neck.

"Dr. Jeffray, the distinguished Professor of Anatomy, having, on the preceding day, requested me to perform the galvanic experiments, I sent to his theatre with this view, next morning, my 'minor' voltaic battery, consisting of two hundred and seventy pairs of four-inch plates, with wires of communication, and pointed metallic rods with insulating handles, for the more commodious application of the electric power. About five minutes after the police officer arrived with the body the battery was charged with dilute nitro-sulphuric acid, which was speedily brought into a state of intense action. The dissections were skilfully executed by Mr. Marshall, under the superintendence of the professor.

"*Experiment* 1*st.*—A large incision was made into the nape of the neck, close below the 'occiput.' The posterior half of the atlas vertebræ was then removed by bone forceps, when the spinal marrow was brought into view. A profuse flow of liquid blood gushed from the wound, inundating the floor. A considerable incision was at the same time made in the left hip, through the great gluteal muscles, so as to bring the sciatic nerve into sight; and a small cut was made in the heel. From neither of these did any blood flow. The pointed rod connected with one end of the battery was now placed in contact with the spinal marrow, while the other rod was applied to the sciatic nerve. Every muscle of the body was immediately agitated with convulsive movements, resembling a violent shuddering from cold. The left side was most powerfully convulsed at each renewal of the electric contact. On moving the second rod from the hip to the heel, the knee being previously bent, the leg was thrown out with such violence as nearly to overturn one of the assistants, who in vain attempted to prevent its extension.

"*Experiment 2nd.*—The left phrenic nerve was now laid bare at the outer edge of the sterno-thyroideus muscle, from three to four inches above the clavicle, the cutaneous incision having been made by the side of the sterno-cleido mastoideus. Since this nerve is distributed to the diaphragm, and since it communicates with the heart through the eighth pair, it was expected, by transmitting the galvanic power along it, that the respiratory powers would be renewed. Accordingly, a small incision having been made under the cartilage of the seventh rib, the point of the one insulating rod was brought into contact with the great head of the diaphragm, while the other point was applied to the phrenic nerve in the neck. This muscle, the main agent of respiration, was instantly contracted, but with less force than was expected. Satisfied, from the ample experience on the living body, that more powerful effects can be produced in galvanic excitation by leaving the extreme communicating rods in close contact with the parts to be operated on, while the electric chain or circuit is completed by running the end of the wires along the tip of the plates in the last trough of either pole, the other wire being steadily immersed in the last cell of the opposite pole, I had immediately recourse to this method. The success of it was truly wonderful. Full, nay, laborious breathing instantly commenced. The chest heaved and fell, the belly was protruded and again collapsed with the relapsing and retiring diaphragm. This process was continued without interruption as long as I continued the electric discharges.

"In the judgment of many scientific gentlemen who witnessed the scene, this respiratory experiment was, perhaps, the most striking ever made with a philosophical apparatus. Let it also be remembered that for full half an hour before this period the body had been well nigh drained of its blood, and the spinal marrow severely lacerated. No pulsation could be perceived meanwhile at the heart or wrist; but it may be supposed that but for the evacuation of the blood—the essential stimulus of that organ—this phenomenon might also have occurred.

"*Experiment 3rd.*—The supra-orbital nerve was laid bare in the forehead, as it issues through the supraciliary 'foramen' in the eyebrow; the one conducting rod being applied to it and the other to the heel; most extraordinary grimaces were exhibited every time that the electric discharges were made, by running the wire in my hand along the edges of the last trough, from the 220th to the 270th pair of plates; thus, fifty shocks, each greater than the preceding one, were given in two seconds. Every muscle in his countenance was simultaneously thrown into fearful action; rage, terror, despair, anguish, and ghastly smiles, united their hideous expression in the murderer's face, surpassing far the wildest representations of Fuseli or a Kean. At this period several of the spectators were forced to leave the apartment from terror or sickness, and one gentleman fainted.

"*Experiment 4th.*—The last galvanic experiment consisted in transmitting the electric power from the spinal marrow to the ulnar nerve, as it passes by the internal condyle at the elbow; the fingers now moved nimbly, like those of a violin performer; an assistant who tried to close the fist, found the hand to open forcibly in spite of his efforts. When the one rod was applied to a slight incision in the tip of the fore-finger, the fist being previously clenched, that finger extended instantly; and from the convulsive agitation of the arm, he seemed to point to the different spectators, some of whom thought he had come to life. About an hour was spent in these operations."

"In deliberating on the above galvanic phenomena we are almost willing to imagine that if without cutting into and wounding the spinal marrow and blood-vessels in the neck, the pulmonary organs had been set a playing at first, (as I propose by electrifying the phrenic nerve, which may be done without any dangerous incision), there is a probability that life might have been restored. This event, though little desirable with a murderer, and, perhaps, contrary to law, would yet have been pardoned in one instance, as it would have been highly honourable and useful to science. From the accurate experiments of Dr. Philip, it appears that the action of the diaphragm and lungs is indispensable towards restoring the suspended action of the heart and great vessels subservient to the circulation of the blood."

There is represented above, the body of a man, who was living an hour before—life having ceased from asphyxia. Suddenly his digestion and respiration were brought to a stand. The vital actions operated no longer. There was no supply of vital electricity to carry on the functions of life, and there was of necessity physical death. Since death was produced by cutting off the supply of electricity, on which vital action depends, the substitution of a supply from an apparatus outside, and independent of the body, should have revived the vital operations. In so far as muscular action is a vital operation, this was effectually accomplished in the above experiments; but there was no reproduction of the internal operations of digestion and assimilation. There was no attempt at this, and it would have been impossible to have made the two experiments on the same subject. In so far as the application of electricity to the muscular part of the system was concerned, the experiment was perfectly successful, as the action was as powerful and general as if it had been from the sensorium that the power had been derived; and if the internal chemical operations which cause vital changes could have been represented, there is no doubt but that the same electric power would have been sufficient for the purpose. The respiratory muscles were brought into operation, and the respiration was apparently reproduced. At that period, auscultation was little known, otherwise it might have been discovered whether vesicular respiration had been restored.

In the *Medico-Chirurgical Review* for 1835,* and copied from a late American contemporary (the *Baltimore Medical Journal*), there is an account of some experiments performed by Dr. Dunbar of Winchester, Virginia, similar to those above mentioned.

"Negro Ben, the subject of these experiments, aged twenty-six, was a stout well-built subject, the muscular tissue of the body was remarkably well developed, indicating great power. He was suspended from the gallows about thirty-five minutes, and in ten minutes after being cut down was delivered to a professional friend by the sheriff for me, and brought to a room (where everything was arranged for the experiments) which had been liberally granted by the mayor, adjoining the town hall. The body was immediately placed on the operating table. The acid mixture (dilute muriatic acid) was thrown on the plates as soon as the conveyance bringing the body appeared in sight. It was discovered from the unusual freedom of motion in the neck, that it was dislocated—or, as it is called in common language, the neck was broken; and upon cutting down in a subsequent stage of the experiments, it was satisfactorily ascertained that the first and second vertebræ (atlas and

* Medico-Chirurgical Review for July, 1835.

dentata) were separated by a space sufficient to admit the end of the little finger. The appearance of the face was quite natural, and seemed as if the unhappy subject of the justly offended law had passed from life with none of those struggles and dreadful agonies which attend the throes of dissolution, and particularly in this most horrible mode of causing death.

"The experiments were now commenced by a gentleman, to whom was assigned the anatomical part, exposing, by a very handsome dissection, an important nerve in the neck which supplies the nervous power to the lungs and stomach (par vagum or pneumogastric). A long silver needle, similar to those used in acupuncturation, was now introduced through the space between the ribs, deep into the substance of the heart. The object of introducing a needle into the heart was to endeavour to ascertain whether any irritability remained, and to attempt to throw some light on a disputed question, whether the heart was susceptible of excitation by the galvanic fluid.

"The positive pole of the battery was applied to the nerve (par vagum), and the negative pole to the silver needle in the heart. There was no perceptible action of the heart, as it would, in all probability, have been evidenced by the quivering motion of the needle, if it had taken place: and in no way that we could discover, was its irritability evidenced, either by the simple introduction of the silver probe, or the action of the galvanic fluid. But the effect on the other parts was very evident. The muscles of the neck and chest were affected by strong convulsive twitchings, most strikingly displayed in those muscles called by anatomists platysma myodes, sterno-thyroideus, and mastoideus, pectoral and intercostal muscles. There was also a convulsive motion of the muscles in the region of the stomach, and a contraction of the muscles of the throat, as in the act of swallowing.

"A needle was now inserted into the tendinous head of the diaphragm, the positive wire of the battery applied to the par vagum nerve, and the negative to the needle. The result was a slight convulsive motion, extending over the chest and abdomen. The contraction and relaxation of the diaphragm was very evident, from the protruding and relaxation of the abdominal muscles; the effect seemed to increase as the acid had time to act on the battery. The positive wire was now applied to a needle inserted into the seat of the phrenic nerve (a nerve distributed to the diaphragm, and has an important influence in the function of breathing). An incision was now made, down to the tendinous head of the diaphragm, and the other wire (negative) applied to the incision. The result was very similar to the preceding experiment, with the addition of an agitation of the chest, compared by an intelligent gentleman present, and a close observer, to that of a person affected by hiccough.

"I think it proper to notice, at this stage, a peculiar action of the galvanic fluid on the nerve and muscular fibre, observed by myself, and confirmed by one of the gentlemen assisting me. The positive pole, whenever it touched the nerve or muscle, produced an action, or whitening, very similar to that which is produced by lunar caustic when applied to an exposed muscle.

"A nerve above the middle arch of the eye-brow (supra-orbital) was now exposed, and the positive pole applied to it, and the other below the lower lid. The result was a contraction of the muscle, causing a natural wink, and an opening and closing of the eye-lids, which was compared to that when the eye closes in a living person, from fear of being injured by some offending object being thrust at the eye. There was also a contraction of the muscles of the cheek, similar to what is seen in some persons who suffer from neuralgia of the face—or aptly likened by a friend to that motion of the cheek when an effort is made by the motion of the face alone to drive off an annoying fly which has settled upon it, without being at the pains to raise the hand for that purpose.

"In the next experiment, a silver needle was introduced into the facial nerve, one pole applied to it and the other to the cheek. The effect was slight motions of the face, and distention and contraction of the sides of the nostrils, resembling much the expression of disdain. The effect on this and the preceding nerve was very slight compared with that produced by Dr. Ure, and so vividly painted by him. He says, 'the expressions of rage, terror, anguish, and ghastly smiles were produced, and united their hideous expression in the murderer's face, surpassing the wildest representations of a Fuseli or a Kean.' In these experiments on the muscles of expression, with the exception of the expression of disdain, as before mentioned, none of those wonderful plays of the features were well marked, which are so manifest when the countenance is animated by the mind, in its varying conditions of wild passion and pleasurable emotion.

"The nerve going to the tongue (hypoglossal or ninth pair) was now touched by the positive pole. An interesting result ensued in the production of motion of the tongue alone. The positive wire applied to the silver needle inserted in the facial nerve, and the negative to the tip of the tongue, a very striking effect was produced, characterizing this as one of the most interesting experiments performed. The result was a rapid vibratory motion of the tongue, compared by several gentlemen to that of a serpent's tongue when alarmed or enraged. There was also a swelling or bulging out of the flesh or muscles under the lower jaw, which was agitated by a quick vibratory action, and one gentleman thought he heard the teeth striking together. The next experiment was the application of the wire to the muscles which assist in closing the lips and mouth. The result reminded me of the action of the lips when a person is muttering to himself, or about to utter words in a soft, low voice—or, in the words of a valued friend, extracted from the notes furnished me, the effect, in his view in this experiment, was as follows:—'The application of the galvanic influence in this experiment really did appear like animation; the lips acquired a motion precisely like those of a person reading to himself; and I do not know if this was not the most natural and pleasing experiment.' The expression of countenance of the criminal, in this stage of the experiment, caused a stare of amazement in many of the spectators.

"A nerve (median) in the arm was now exposed, and an incision made into the middle on the little finger—positive pole applied to the nerve, and negative to the little finger. A most interesting and vivid display of the galvanic power was the consequence. The arm raised itself from a horizontal position with so much strength and violence as to require the exertion of considerable power in the operator to restrain its freedom. It repeatedly made efforts resembling those of life to jerk its hand away from his grasp, and when permitted, struck against the chest with great violence, settling in the attitude of a pugilist when prepared to defend from the attack of an adversary. The motions of clenching and opening the hand, and the drawing up and extending the arm, during the progress of this experiment, was described by one gentleman something like the motion of one sowing grain in a field, if the body had been erect. The principal muscles of the arm were contracted so as to form a swelling, and their lines of demarcation were very conspicuous on the skin. During part of the time, the forearm continued in its fixed position, and exhibited a tremulous motion, resembling that of the limbs of an animal immediately after receiving a blow on the head. The fingers were clenched on the hand in this experiment. These phenomena continued about half a minute, and then ceased. The poles of the battery were then removed, and soon after re-applied. The same phenomena ensued with equal violence, upon the repetition of the experiment, several times. The ulnar nerve was then transfixed with an acupuncturing needle in the elbow, and positive pole applied to it, and negative to the little finger. The effect produced was a rapid motion of the fingers, but in a manner which was particularly striking to all who witnessed their action. Instead of being flexid at the same time, they moved sometimes rapidly, at others in a more gradual motion, but alternately, being greatest in the little finger, which was the most flexed, and diminishing towards the fore-finger. The motion of the fingers in this experiment was compared by one to that when playing on the flute, and by others to the action of a violin performer when in playing he works upon the strings of that instrument.

"These two experiments were decidedly the most remarkable, and exhibited the power of this most wonderful agent more completely than any other performed, and excited great and renewed surprise and astonishment at the effect of this magical influence, which could produce such wonderful phenomena, and so closely resembling those of a living person, in the limbs of a body whose spirit had deserted it for ever.

"A needle was now introduced into the spinal marrow through the vacancy caused by the separation of the vertebræ, and another inserted into the heart and head of the diaphragm, but little effect was produced, other than the quivering motion of the muscles of the neck and chest. The spinal marrow being now completely exposed in the neck, positive wire applied to it, and the negative to the foot, the effect was not remarkable; there was a slight convulsion of the muscles of the limb.

"A needle being now inserted into the sciatic nerve, and another in the ham, there resulted a spasmodic action of the large muscles of the thigh; when the needle was changed to the inside of the foot, and the positive pole applied to the one in the ham, a much more marked and decided effect was perceived. The leg vibrated strongly (the subject lying on the abdomen); a swelling of the muscles of the calf of the leg; the toes were flexed, and extended with considerable freedom at an angle quite as much as when extended in the act of stepping or walking.

"With these the experiments ceased, the body having become externally cold, and the irritability sensibly exhausted; the power of the battery appeared also very much diminished, which will account for the weakened action produced in the last experiments."

The difference in the results in the two sets of experiments depended altogether on the difference of the power of the apparatus used in each case. In Dr. Ure's case, that apparatus was six times the power of that of Dr. Dunbar; and this is quite sufficient to account for the difference in the results. The effects were the same in kind; they only differed in the extent of power. The muscular action, in the one case, represents that of an energetic and powerful nervous force, and, in the other, a force comparatively feeble. The former represents the case of a strong man, with well-developed organs for producing a large amount of vital electricity. His respiratory organs are large, and his digestion is sound and active. The action produced by the strong electric current was powerful and almost irresistible. The case of the negro represents the condition of one that is feeble and ill supplied with vital electricity; and, in point of fact, he had a comparatively small portion of the artificial supply.

There were none of the powerful actions of the strong man of Dr. Ure: there were the feeble manifestations of one labouring under disease. It is like one who is a dyspeptic, and at the same time lame, in the respiratory apparatus.

These experiments demonstrate that, by a sufficiently powerful and properly adapted electric apparatus, the muscular functions can be performed with the same vigour by the supplemental electric current as by that of the nervous current of the living animal body. If a good conducting provision, of a feebler abstracting power than the wire of the battery itself, had been applied to the positive wire of Dr. Ure's galvanic apparatus, it would have withdrawn a portion of electricity before it reached the subject under experiment, and the manifestations would consequently have been feebler and less perfect. This will represent the operation of the good conducting power of a negative condition of the earth in withdrawing the vital electricity from the human body, and thus weakening the power of the nervous system,—weakening its action in performing the vital operations in the human system, in the same manner as the manifestations produced by Dr. Ure would have been less strong and less perfect if the current had been weakened by an abstraction before it reached the body under operation.

Dr. Letteby states that the "notion has long been entertained by our ablest physiologists, as, indeed experiment shows, that a current of electricity sent along the efferent and afferent nerves produces effects precisely analogous to those which are consequent on the transit of nervous forces. If it be sent along a motor nerve, muscular action is the result; along sensitive ones, we effect the sensation peculiar to that nerve. Thus, by means of a simple galvanic current passed through the eye, we produce the effect of light; through the auditory nerve, that of sound; and the nerves of taste and smell may be similarly acted upon."

Dr. Wilson Philip has asserted that he can produce the secretion of the gastric juice by sending a current along the divided pneumogastrics. "But, unquestionably," says Dr. Ure,* "the most precise and interesting researches on the relation between voltaic electricity and the phenomena of life are those contained in Dr. Wilson Philip's Dissertations, in the Philosophical Transactions, as well as in his Experimental Inquiry into the Laws of the Vital Functions, recently published.

"In his earlier researches, he endeavoured to prove that the circulation of the blood and the action of the involuntary muscles were independent of the nervous influence. In a late paper, read in January, 1816, he showed the immediate dependence of the secretory functions on the nervous influence.

"The eighth pair of nerves distributed to the stomach, and subservient to digestion, were divided by incisions in the necks of several living rabbits. After the operation, the parsley which they ate remained without alteration in their stomachs, and the animals, after evincing much difficulty of breathing, seemed to die of suffocation. But when, in other rabbits similarly treated, the galvanic power was transmitted along the nerve below its section to a disc of silver placed closely in contact with the skin of the animal opposite to its stomach, no difficulty of breathing occurred. The voltaic action

* Dr. Ure's Chemical Dictionary.

being kept up for twenty-six hours, the rabbits were then killed, and the parsley was found in as perfectly digested a state as that in healthy rabbits fed at the same time; and their stomachs evolved the smell peculiar to that of a rabbit during digestion. These experiments were several times repeated with similar results.

. . . . . . "Rabbits were rendered insensible by a blow on the occiput; the spinal marrow and brain were then removed, and the respiration kept up by artificial means; the motion of the heart and the circulation were carried on as usual.

. . . . . . "Hence it appears, that the galvanic energy is capable of supplying the place of the nervous influence, so that while under it, the stomach, otherwise inactive, digests food as usual. I am not, however, willing to adopt the conclusion drawn by its ingenious author, 'that the identity of galvanic electricity and nervous influence is established by these experiments.' They clearly show a remarkable analogy between these two powers, since the one may serve as a substitute for the other. It might possibly be urged by the anatomist, that as the stomach is supplied by twigs of other nerves which communicate under the place of Dr. Philip's section of the 'par vagum,' the galvanic fluid may operate merely as a powerful stimulus, exciting these slender twigs to perform such an increase of action as may compensate for the want of the principal nerve. The above experiments were repeated on dogs with like results, the battery nerve being so strong as to occasion painful shocks."

In these experiments of Dr. Philip, there is an exhibition of the action of the principal vital operation by electric power alone. There were respiration, digestion, and circulation; and if the artificial operation had been long enough continued, there would have been the resulting operations of assimilation, secretion, and excretion. If the more important acts of physical life can be performed by electricity, there is no doubt of its ability to perform the lesser efforts of corporeal existence.

"The results of Dr. Philip have been recently confirmed by Dr. Clarke Abel, of Brighton, who employed in one of the repetitions of his experiments a comparatively weak, and in another a considerable power of galvanism.* In the former, although the galvanism was not of sufficient power to occasion evident digestion of the food, yet the efforts to vomit, and the difficulty of breathing, constant effects of dividing the eighth pair of nerves, were prevented by it. The symptoms recurred when it was discontinued, and vanished on its re-application. 'The respiration of the animal,' he observes, 'continued quite free during the experiment, except when the disengagement of the nerves from the tinfoil rendered a short suspension of the galvanism necessary during their readjustment.' 'The non-galvanized rabbit breathed with difficulty, wheezing audibly, and made frequent attempts to vomit.' In the latter experiment, in which the greater power of galvanism was employed, digestion went on as in Dr. Philip's experiments."—*Jour. Sc.* IX.

There is no doubt but that these experiments could be multiplied *ad infinitum*, but the facts deduced by those already cited are perfectly satisfactory.

* Dr. Ure's Dictionary of Chemistry, article *Galvanism*.

One may urge the objection, that if electricity can perform the operation of digestion in the stomach, why not also independently of this organ? Before this could well be done, it would be necessary to imitate the inimitable contrivance which the God of Nature has instituted for the operation. When we contemplate the complex nature of the structure of the different organs which are engaged in the process of digestion, the extreme tenuity of their texture, requiring the help of a powerful microscope to see, and that but imperfectly, the extremely minute structure of which these organs are composed, ought this to discourage further investigation?

Since this structure can be seen but by the most advantageous means, is it unreasonable to conclude that the puny efforts of man cannot manipulate after the manner of nature?

Pfaff and Ahrins assert that they have detected free electricity traversing the nerves both in man and the lower animals, and the latter observer states that the current is increased after taking spirituous drinks, but diminishes as the body cools; in other words, it is in the ratio of the chemical changes of the respiration.

Zantideschi and Dr. Favio assert that in all warm-blooded animals there are two electro-vital or neuro-electric currents, an external and cutaneous, which directs itself from the extremities to the cerebro-spinal axis. These two currents grow weaker as life ceases or as pain is felt, while the convulsive or voluntary movements give a strong current or increase the discharge.

Dr. Faraday observes, that from the time it was shown that electricity could perform the functions of the nervous influence, he has had no doubt of their close relation, and that they probably are effects of one common cause.

This is the opinion of Dr. Wilson Philip, Wollaston, Treveranus, Carus, Prevost, Dumas, Matteuci, Meisoner, and many others. Sir J. Herschel says that "the present state of electrical science warrants the conjecture that the brain and spinal marrow form an electrical organ, which is spontaneously discharged along the nerves at brief intervals, when the tension of the electricity reaches a certain point. Dr. Letteby remarks that all vitality results from chemical action, and the chemical action gives rise to electricity. Electricity in motion gives rise to combinations and decompositions, and the nervous power is the same. But though we have learned this much concerning the phenomena of life, we are yet, perhaps, on the threshold of what we may be permitted to know. Nature seems to have exhibited glimpses into her most intricate operations; has lifted the veil which before formed an impenetrable screen to the comprehension of her sublimest wonders."

The structure of the nervous system gives countenance to the views above cited, as MM. Prevost and Dumas have long ago stated, that when a nerve is examined by the aid of a powerful microscope, it is found to be composed of many filaments, equal in thickness, continuous through its whole course, and each made up of four elementary fibres: when the nerve approaches its ultimate distribution, the filaments separate from one another, and always cross the muscular fibres at right angles; but before this separation takes place, the course is generally parallel with that of the muscular fibres. The filaments are not ultimately lost in the muscular tissue, as is commonly supposed, but either go round a certain number of muscular fibres, and return into the twig from which they sprang, or, after crossing the muscle, enter another nervous twig running parallel to the former. In this way it appears that, in their ultimate distribution, the nervous filaments are so many circular threads or conductors parallel to one another, and at right angles to the fibres of the muscle they supply; consequently, when a stream of galvanic electricity is passed into a nerve, these threads will become the conductors of so many parallel electric currents, and therefore have an attraction towards each other.

And Dr. Letteby states, that "we find that the termination of nerves is in loops, that they return on themselves at both extremities, and this completes their current. The one loop is in the brain or cord, the other at the periphery; and we observe, moreover, that both these loops are imbedded in an intricate plexus of capillary vessels. It is in these capillaries that the great chemical changes of the body are being effected, and we may, from these data alone, speculate rather extensively upon the phenomena of reflex action. Electricity sent along nerves gives rise in the living organism to effects precisely similating the vital, and during the performance of the vital functions, electricity can be detected traversing the body."*

* A number of individuals, in their own persons, may have a demonstration that the heat evolved during the vital operations is really electricity. Those individuals, whose corporeal manifestations are

Although contending for the necessity of electricity to perform the vital operations, yet this is separate from the living intelligent and spiritual principle that governs over all. The nervous system, with its electric forces, is the instrumentality which is under its power and direction. It is the servant of the living principle. This it is that wills before an action can be performed, before a muscle can move; and the will is obeyed as speedily as a spark along an electric wire.

From the foregoing data it may be admitted, that it amounts to demonstration that the electricity evolved during respiration and assimilation, both primary and secondary, is that which supplies the nervous power; and that the structure of the nervous

carried on with integrity and vigour, and who have the cellular substance on the exterior of the body well filled up, are in the best position to observe this phenomenon. The author knows several individuals who have the cellular substance well filled up, and who have observed electric sparks issue from their bodies. The air must be dry, either by the low temperature of winter or the desiccating heat of summer. These persons have observed, in this dry state of the atmosphere, that electric sparks escaped from the surface of the body, just when they were throwing off the flannel vestment next the skin. Now any individual whose corporeal condition corresponds to the above description may observe this phenomenon in his own person. There is constant radiation of electricity from every one who is perfectly healthy, although he may not be able to observe its escape. The reason of the difference in this respect between the spare man and his more corpulent neighbour is the following:—The redundant electricity given off during the vital operations radiates freely from the spare man, as he has no provision around his person for preventing the radiation of this element. The rotundity of his differently-conditioned neighbour depends on a large supply of fat, which occupies his cellular substance; and this fat is a bad conductor of electricity, and presents an obstacle to its free radiation, causing it to accumulate under the coating of fat, and pass through in larger quantities at a time, sparking as it issues. When the air is moist, the electricity of the round man and the spare man is carried noiselessly away, as the air in this condition is a good conductor.

system favours the conclusion that the nervous forces are affected on the principle of a galvanic arrangement. The very structure of the vegetable bodies, forming the food which supports the body, gives countenance to this conclusion. This will appear by exhibiting here an exemplification of the composition of one of those vegetable bodies, as well as the ultimate composition of the animal body, that they may be contrasted together :—

BLOOD OR FLESH.		WHEAT.	
Carbon	51.96	Carbon	46.1
Hydrogen	7.25	Hydrogen	5.8
Nitrogen	15.7	Oxygen	43.4
Oxygen	21.30	Nitrogen	2.3
Phosphorus		Phosphorus	
Soda		Potash	
Lime		Soda	
Potash	4.42	Lime	2.4
Magnesia		Magnesia	
Iron		Iron	
Chlorine		Sulphur	
Sulphur		Chlorine	
	100.00		100.00

The constituents of grain, in their ultimate form, do not exactly coincide with those of the blood; but the nourishing nitrogenous principle contained in the grain, viz., vegetable albumen, is almost identical in composition with the albumen of blood. In the process of separating this albumen from the other proximate principles in the grain, electricity is given off.

Corn, rye, and barley have nearly the same composition as wheat. Besides the albumen, there is also a large quantity of starch in the grain. This is so nearly the same in composition with the fat of the body, that it will provide the supply necessary for the wants of the animal structure. When we thus examine the ultimate composition of the cereals, we find that the Author of nature evidently intended that they be used to support the animal frame, as they are found in their construction to bear a close analogy to the animal body. There can be no doubt in the mind of any one, that there are here means to an end. The animal loses in substance, if he is deprived of this provision for any length of time. Now each of the primary constituents of these cereals is surrounded by a large quantity of electricity, and this is one source of the electricity which will be available to supply the nervous exhaustion which takes place during the vital operations.

The constituents of the tissues of the body are continually undergoing changes, the nervous as well as the other tissues, and they are regularly thrown off, and replaced by the fresh supply which is continually provided by the food introduced into the stomach of the living animal. If this supply of food be withheld for any improper length of time, the tissues will waste, and emaciation will inevitably result. Not only will the tissues disappear, but the nervous power will become enfeebled and inadequate to act upon muscular matter with the necessary amount of power. If food be completely withheld, the whole of the tissues will be so reduced in bulk and power that the animal will die. It must follow, if, because food is withheld, the tissues waste and the nervous power becomes feebler and feebler, and ultimately becomes extinct, that there is provision for the supply of the nervous power bound up in the nourishment which is taken into the stomach. From what portion of the nourishment, then, is the supply for the nervous power derived? When the primary constituents of the food are examined, there is not one of them whose action, apart from the animal system, resembles, in the slightest degree, the action of the nervous power. Phosphorus, of all the ponderable constituents of the body, enters most largely into the composition of the nervous substance; but it can only feebly imitate nervous action in its separate condition; and, besides, the smallness of the quantity which enters into the composition of the nervous substance would shut out all idea that this substance can be the source of nervous power. Now, when we find that there is an element surrounding in large amount every primary constituent of the food that is taken into the body, and that this element, in its action out of the body, exhibits an action not unlike nervous power, and when applied to the nerves of the recently dead body, the resulting action is exactly identical with that produced by the operation of the nervous power, is there any straining in the conclusion that the food taken into the stomach and subjected to digestion, and the air inspired in respiration, eliminate, during both these processes, a large quantity of the electric fluid, which fluid is a provision for supplying nervous exhaustion? The electricity is given off during the healthy action of the human body, and a larger supply is provided than is required, as it is constantly given off by radiation. So jealous has nature been that the animal frame be well supplied with this element, that the respiration and all other processes are employed to provide the supply.

In support of the position that nervous power and electricity are identical, is the fact of the necessity of adding to the ordinary allowance of food, wherever great muscular effort is required. As a general rule, the addition to the food must be in proportion to the amount of muscular power brought into action; and the greater the activity of the digestive organs for producing the assimilation of the food, the greater will be the evolution of vital electricity. To obtain the full amount of nervous power capable of being brought into action, the respiratory organs must be well developed and in a sound condition, as the larger the capacity for inhalation and exhalation so will be the amount of evolution of electricity from the air used in the respiratory process. The increase of the respiratory action, when an increased effort is made, as in racing or ascending a height; the enlarged quantity of food required by those who are engaged in severe muscular exertion (in which also the respiration is increased), all testify that there is a connexion between the increased action of these operations and the increase of power required and produced.

It is always found that in proportion as the lungs are well developed, and the digestive organs are sound and active, so is the strength of the individual, and his ability to continue and persevere in exertion.*

"The brain, the ganglia, and the nerves, may be likened to galvanic batteries and their conducting wires; and there is no doubt that the nervous influence and the electric fluid bear a very consider-

* A reviewer in the London Medical Times and Gazette, Feb. 1858.

able analogy to one another; but analogy is not identity, and, even admitting that electric and nervous influence may be more closely allied than they are now supposed to be, the question arises, how the battery is set in motion, how it is interrupted, and what are the results of its action?"

Admitting the truth of this principle, that nervous power and electric power are identical, it will follow that suspension or derangement of those provisions which nature has furnished for preserving a continual supply of vital electricity cannot fail to affect the system prejudicially, in proportion to the amount of the abstraction of the vital fluid.

The sensations which accompany the onset of almost any disease have all reference to an impression on the nervous system. There is a chilliness which cannot be traced to an alteration of the general temperature, and there is an attendant debility,—a reduction of the strength,—which does not depend on any known cause. But the phenomena are more striking, when we contemplate the ordinary symptoms which usher in almost every form of serious illness; and the conclusion at once made by the mind is that the first morbid impression is on the nervous system. The tumultuous form of nervous action which constitutes a rigor, the usual precursor of severe disease, conveys the sensations to those who are the subjects of it, as if there had been a sudden abstraction of heat,—as if a screw had become loose in the animal machine,—as if the whole mechanism of the frame had become disordered. Coincident with this sensation of escape of heat, there is a general derangement of the secretions and a sudden failure of muscular power.

In consequence of the uncertainty which has hitherto hung over the cause of disease, there has been, at all times, a great deal of groping in the dark, recourse being had to the very convenient alternative, cold, and, in some cases, to an unseen, inappreciable agent, called infection; but it is difficult to know on what theory, than that here advocated, a more satisfactory explanation could be advanced of the cause of the symptoms above indicated.

The electricity evolved during galvanic action, and the nervous power, have been demonstrated above to be identical: the nervous action has been successfully substituted by electricity.

In galvanic arrangements, when the supply of electricity is small, the stream feeble, and the current broken, and communicated in a succession of sparks, the effects will be proportionally weak, and the operation inefficient. On the contrary, when the supply of electric fluid is abundant, the stream strong, and the current unbroken, as in Dr. Ure's case, the power exerted by it will be proportionally increased, and its operation effective. So in nervous currents, when the supply of vital electricity is curtailed by disease of the respiratory organs, and suspension or derangement of the assimilating organs, the amount of electricity given off by these processes must be lessened in proportion to the extent of disease in the former, and the suspension or derangement of function in the latter. Hence will result imperfect performance of those vital operations which depend on a large supply of nervous power. On the contrary, where the respiratory organs are healthy, the organs of assimilation active and sound, and every vital action vigorously performed, there is a combination of circumstances which constitutes perfect health.

It will now be proper to point out how this theory may be applied to account for the remote cause of disease. In the absence of rational principles on which to found their observations, authors have been tempted to indulge in all sorts of imaginary causes, and that which is the most obscure is the most generally received. As an example of this, the imaginary agent most commonly accused of producing pestilential disease is *miasm.* Now, so far as I know, this miasm is not known as anything tangible,—anything appreciable by any of the senses; no search has found out its reality: yet it has been long acknowledged as an operating cause in producing epidemic disease. When we take into account the principles here advocated,—viz., that electricity and nervous force are identical, that the electricity evolved from the air in the lungs during respiration, and that separated from the ingesta during assimilation, is that which supplies the vital electricity to the nervous system, and that any cause which hinders the supply or suddenly and to a great extent withdraws it after being supplied,—there is here an appreciable combination of causes which will injuriously affect the system. "Taking cold" will thus become an easily comprehensible idea. The escape of heat—that is, the withdrawing the electricity from the body—is understood to be "taking cold." The abstraction of vital electricity from a person whose nervous system has nothing to spare, will cause derangements that will be developed in some form of disease; the nervous currents in such circumstances acting on a secreting gland may be insufficient to elaborate from the blood those constituents which are required to form the various secretions; and in this manner may the secretion be imperfectly eliminated, and the depuration of the blood incompletely effected; and the retention of those elements which ought to have been given off will give rise to diseases which result from the vitiation of the fluids of the body.

Independently of all external agency operating on the body in the form of what is generally viewed as contagion, there are in the circumstances supposed above, changes in the blood sufficient to account for an attack of serious disease. It is now generally admitted by physiologists that the blood in almost all serious diseases becomes altered and deranged. The nervous system is the starting-point of disease; the blood is secondarily affected in consequence of the inability of the nervous system to withdraw from it those elements which ought to be deposited to maintain the body, as well as those which are required for the elaboration of the secretions and excretions; and the solids are third in the arrangement of the morbid process. Diseased action in the solids will flow from these alterations in the blood, sooner or later, and that to a larger or smaller extent, according to the constitution of the individual affected. The grosser elements which are left in this fluid will cause, in irritable constitutions, a stretching of the coats, and consequent enlargement of the calibre of the capillaries, before the increased bulk of sanguinous fluid can pass through them, and thus constitute the proximate cause of the pain in inflammation; the seat of pain and inflammation, and consequent swelling, being determined by the tenuity of the walls of the capillaries in the region affected. The propelling power of the heart and arteries, too, will be called into increased exertion, to press the grosser sanguineous fluid through the capillary system, and in this way cause the development of the hard and resistant pulse of acute disease.

The phenomena which are manifested in many diseases give countenance to these views. This may be observed more especially in fever, the most prevalent of all diseases. The very first morbid impression which is felt is lassitude, and, almost simultaneously with this, muscular debility is experienced. This is the starting-point of the disease, the first departure from healthy action. Here is evidently indicated a debilitating impression on the nervous system, a reduction of its power exhibited in muscular feebleness; and then follow derangements of the various secreting organs of the body, because of the inability of the nervous power to effect the elimination of their secretions.

Dr. Copland, in his article on Fever, sect. 10,* remarks, that "The early and remarkable lesions of the secreting functions, and the generally imperfect actions of the excreting organs, especially in the early stages, are important, not merely as they form a part of the circle of morbid actions characterising the disease, but as they especially lead to most of the ulterior changes and complications observed in its advanced course. They evidently depend, at their commencement, upon deficient organic nervous power, occasioning at first imperfect or scanty secretion and excretion; and, at later periods, upon

* Dictionary of Practical Medicine, vol. i. p. 895.

the morbid or vitiated state of the blood, the secretions and excretions then frequently becoming free and copious, but altered from their healthy characters."

The phenomena thus described by Dr. Copland are just such as might have been pre-supposed from the principles here advanced. The deficient organic nervous power is just a consequence of the exactions which have been made on the general nervous system by the exhausting influences which have been operating on the surface of the body producing deficiency of nervous power.

The heart and arteries soon evince by their disturbed action how much the system sympathises with the general derangement. The circulation becomes hurried, accompanied by lesion of its functions, which may arise from the irritating nature of the altered condition of the blood, which requires a greater force to propel it through the capillaries.

It is well known that, in many diseases besides fevers, serious alterations take place in the blood, both as regards the constituents of which it is composed and its vitality,—losing the power of coagulating. It is acknowledged by the best authorities to be in a state of vitiation, altered both "in quantity and quality in the relative proportion of its constituents, and even of the vitality of this fluid."

CHAPTER II.

ON THE AGENCIES WHICH OPERATE ON THE HUMAN BODY TO PRODUCE DISEASE.

In order to ascertain how far these principles accord with sound philosophy, and how far they are corroborated by the phenomena observed in nature, and especially in so far as disease is concerned, we will examine how they can be applied to account for the prevalence of epidemic disease. This will be best accomplished by examining what are the agencies which operate in withdrawing electricity from the human body, and then considering what are the conditions of the animal frame which prevent the natural supply of electricity.

There are many agencies which abstract caloric from the animal body, but that which is most generally operative is that universally diffused element, water. More especially does it operate thus when it is being changed into vapour. When water is assuming the form of vapour, it absorbs an immense quantity of electricity, and it is during this process that portions of the earth, and the objects on it, are, for the time being, deprived of a large amount of electricity. Now, it is on the principle that evaporation withdraws from the animal economy the electricity which is evolved during the vital operations above described, and thus almost exclusively, that injurious influences are exerted so generally, especially on the predisposed, as is sufficient to cause epidemic and wide-spread disease. In tropical countries rain falls in much larger quantities than in countries of a higher latitude, and it has all to be raised again by the process of evaporation. It is the solar heat radiated from the earth, and from those bodies which are placed on it, that provides the heat to raise the vapour. It is when this evaporating process is going on that electricity is carried up, while the earth, with the objects on it, is to a certain extent deprived of electricity.

So constantly is humidity associated with the existence of endemic and epidemic disease, that it may be stated as a general rule, that, in proportion to the amount and rapidity of evaporation, in any given situation, so will be the extent and virulence of pestilential disease. In all speculations on this hitherto dark subject, whatever has been conceived to be the cause of epidemic disease, it has been always supposed that humidity contributes to its virulence, and is indispensable for its full development. Hence, it is found that diseases are most prevalent in situations where moisture is most easily and most copiously generated,—in valleys, on the banks of rivers, near shallow marshes, in the vicinity of mangrove plants, and wherever a favourable condition of the surface exists to accelerate the process of evaporation. The rainy season, or rather immediately after it, is well known to be the most sickly in tropical climates. Except in those cases where diseases may depend on a peculiar state of the geological structure of the strata of the situations which are found to be insalubrious, there is always the necessity of moisture to produce the sickly condition of a country. And it is sometimes found, that so intense is the epidemic influence, that even the lower animals are injuriously affected by it. This has been frequently adverted to by different authorities. Dr. Copland states "that several of the seasons, preceding and during the prevalence of pestilential cholera, have been unusually wet, and that increased mortality among the lower animals is often observed at such times." The lower animals being affected, is a proof of the universality with which this cause operates.

There are many accounts of observations which have been made in various parts of the world, showing that active evaporation and moisture were present in situations where epidemic diseases prevailed. That it was not merely concomitant is generally admitted, as it is maintained by those who believe in the existence of malaria, that without moisture their miasm lies dormant; and those who consider that the disease is communicated by some unknown agency from one person to another, always admit the necessity that moisture be present to produce activity in the morbific agent. The existence of this contrariety of opinion may have prevented the production of many facts which might have assisted in clearing up this dark and very important subject. The contagionists confine their attention to discovering what opportunities exist for allowing the sick to approach the healthy, and are satisfied to rest their hypothesis here, if an accumulation of facts of this kind be sufficiently large. With views thus directed, they have passed unnoticed many facts and circumstances which might have been

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useful to be known, such as the topography, the temperature, the facilities for evaporation, the meteorology, the electric relations, &c. The miasmatists, on the contrary, have been careful to bring together many observations of a kind, on which to form rational conclusions. They have collected a great many observations which show that epidemic diseases prevail most frequently in those places where are the greatest facilities for the collection of moisture, and the development of evaporation.

It would be easy to fill a volume with an account of the observations made by those of the latter class of inquirers, who have had an opportunity of living in those situations where epidemic diseases are frequent. It will be enough, however, to make a selection, as far as they can be useful, to illustrate the principles here advocated.

The kind of facts which is required to support the premises here maintained, is an account of those influences which exact from the animal system the inbred electricity, which is being continually evolved during the vital operations. As before observed, it is found that epidemic diseases are most prevalent in the torrid zone, in those situations where there are marshes, or any other combination of circumstances favourable for the development of moisture. Medical men, both in the army and navy, have enjoyed opportunities of observation on this subject, with which their brethren situated in large communities, in temperate regions, have not been favoured; and the facts which they have accumulated will be available in support of the views here advanced.

The black death of the fourteenth century, which in its symptoms bore a close affinity to plague, produced ravages at that remote period which far exceeded in severity all the invasions of pestilence at the present day. It is stated by writers of that age that, in Germany, there had died 1,244,434 inhabitants; and that this country had also suffered, as well as most of the countries of Europe. In Vienna alone, there had died 100,000 of the people. For some time during that gloomy period, 1,200 of the inhabitants died daily; and ordinary sepulture was so impracticable that the dead were arranged in layers in pits around the city. Of the Franciscans alone, a religious order in Germany, there died 124,434. In London, the capital of England, there had fallen 100,000 from this disease. These memorials of the devastations of pestilence at that remote period are so meagre in the details of facts, as well regarding a description of the disease itself and of its process, as of data connected with the state of the localities in regard to drainage, ventilation, topography, meteorology, weather, etc., that no satisfactory conclusion can be drawn from them. Knowledge of this nature might have furnished materials for producing some light as to the cause of this scourge.

Since that period there have been many researches made, and a considerable amount of materials accumulated, which may be serviceable in throwing light on the remote cause of epidemic disease.

The changes which have been produced on the electric relations of the earth have never been fully appreciated, as an operating cause in producing disease. In the tropical regions of our globe, the sun pours down his rays with glowing power, and whilst thus shining, the temperature, otherwise the electric tension, is greatly intensified, and the advantages of a positive electric condition are communicated to the whole of those regions which are operated upon by the concentrated solar influence. It is impossible that such a powerfully operating agent can be in such constant exercise, without materially affecting the animal portion of creation, which is teeming in almost every region of the earth. In proportion as the heating influence of the sun is removed, so will there be left a relatively considered negative condition of that portion of the earth from which the rays of the sun are withdrawn. Hence during the day, the earth and the objects thereon will be in a positive condition, and at night they will be in a negative state, in relation to what they were during the day. The disparity between the night and the day will be affected by the nature of the locality acted upon by the sun. In the desert, or on its margins, there will not be the same difference of electric tension of the day and night as there will be in swamps and like situations. In the former, there is not present the evaporation of moisture, to exhaust from the earth the accession of electric power acquired by the repeated action of the solar rays. This was very effectually experienced by Dr. Livingstone in his recent African explorations. Whilst in the desert, and other dry situations, where it was difficult to procure water to satisfy their thirst, there was no sickness either in him or his party, and they could lie with impunity all night in the open air. On the other hand, his experience was very different when he came to the margins of the lakes and banks of the rivers. He was disabled by fever in a very short time after coming under the action of moist air, and the wet grounds on the banks of the lakes and streams; and he continued to suffer more or less so long as he continued to voyage along the rivers or travel on their banks. This experience of Dr. Livingstone accords with that of all those who have been placed in like circumstances.

Near swamps and other parts impregnated with water, the heat absorbed during the day will continue after sunset to radiate from the earth. Thus the electricity which has contributed to place the locality in a positive condition during the time the sun shone, will be carried off. The evaporation will go on drawing off more and more electricity during the whole night, till the rays of the sun again heat the soil, restoring its positive condition. Hence it is found, that, in swampy districts and those in which there is much moisture, disease is much more liable to attack a person exposed during the night than during the day, when the sun shines; and that there is the greatest danger in the morning, just before sunrise. This depends on the more negative condition of the region during the night, in consequence of the absence of the sun; owing to the operation of the well-known law in electrical phenomena, that electricity will at all times find its equilibrium. For example, an animal exposed to a region which is in a highly negative condition, must, on account of the electricity which is being continually given off during the vital operations, be in a more highly positive state than the ground on which he stands, and must suffer a diminution of that electricity on account of the good conducting power of the ground, and the tendency to equilibrium which exists between the locality and himself. In particular situations in various countries, the evaporation is comparatively slow. This is the case in the swampy regions of Italy. The evaporation is not very copious, but it is constant, and keeps the portion of the country on which the marshes are situated, relatively considered, in a constantly negative condition; which portion of the country will, on this account, continually abstract electricity from the body. Dr. Johnston, in a work published in 1831, makes the following observations on the Italian malaria.*

"A glance at the inhabitants of malarious countries or districts must convince even the most superficial observer, that the range of disorders produced by the poison of malaria is very extensive. The jaundiced complexion, the tumid abdomen, the stunted growth, the stupid countenance, the shortened life, attest that habitual exposure to malaria saps the energy of every bodily and mental function, and drags its victims to an early grave. A moment's reflection must shew us, that FEVER and AGUE, two of the most prominent features of the malarious influence, are as a drop of water in the ocean, when compared with the other less obtrusive but more dangerous maladies, that silently but effectually disorganise the vital structures of the human fabric, under the operation of this deleterious and invisible poison. Yet the English traveller or sojourner in Italy knows little, if anything, respecting these slow and masked underminings of his health, and thinks,

* Change of Air, or the Pursuit of Health, p. 125.

if he escapes the malaria fever of July and August, he has nothing more to dread, but everything to enjoy, throughout the year. Fatal mistake! The foundation of chronic maladies, that render life miserable for years, is every Summer laid in hundreds of our countrymen who wander about beneath the azure skies of Italy. They bring home with them a poison circulating in their veins, which ultimately tells on the constitution, and assumes all the forms of Proteus, harrassing its victim with a thousand anomalous and indescribable feelings of wretchedness, inexplicable alike to himself and his physician. It is the attribute, the character, of all malarious disorders to be slow in their development, when the poison is inhaled in a dilute state, or only for a short time. Many of our soldiers did not feel the effects of the Walcheren malaria till months, or even years, after that fatal expedition. So our countrymen in India often go on for years in tolerable health, after exposure to a malaria, before the noxious agent shows itself in the disturbance of certain functions of the body. The same thing is seen even in England, though on a smaller scale. Those who inhabit marshy or damp situations become, sooner or later, affected with some of the Proteiform maladies engendered by malaria, though they are seldom understood, unless they happen to take on a regular aguish character."

What principles can more satisfactorily account for the multitude of evils and miseries which are above represented, than that the nervous system has been weakened, and that, as a consequence, its powers are less vigorous? There is, in these marshy districts, an abstracting agency operating on the supply of nervous power, and there will, consequently, be an imperfection in the operation of the functions which are performed in the secreting, assimilating, and excreting organs. The consequence of this will be, imperfect elaboration of the various products of the vital operations. Hence will arise the derangements which result from a vitiated circulating fluid. The evaporation from the Italian marshes is comparatively slow, and the abstraction of the power from the nervous system of those in contact with them, is proportionally small and partial, but it is continuous. As a consequence of this, the nervous forces are unfit to eliminate the fluids from the blood in a sound and healthy condition; and those materials, which it is the office of the excretory organs to cast out, are retained. Hence the jaundiced skin and the stunted growth. The stupid countenance may arise from the vitiated fluids circulating through the brain. Since the abstraction of nervous power from the person of an English sojourner, near these Italian marshes, is partial, though continuous, no inconvenience is felt by him for some time. But when he persists, for a certain time, in residing in the marshy locality, and exposing himself to the abstracting influence of the evaporation, his nervous forces become too far reduced to continue the vigorous operation of digestion and assimilation, and this will cause the fluid circulating through the whole body to be imperfectly elaborated. If this unnatural and vitiated state of the blood continue during a long enough period, the whole organization of the body may become depraved, and cause many derangements, producing many Protean forms of disease. "The poison circulating in the veins" is neither more nor less than those bodies which, in the healthy condition of the system, are thrown out, but which—the reduced nervous power of the organs set apart to throw them off, rendering them unable to perform their office—are left in the blood, and cause the consequent derangement. It is not surprising, then, that every form of derangement may arise from a long continuance of this impure condition of the blood. The whole capillary system being kept in an irritable and congested condition, ready to become diseased, there cannot be the healthy deposition of those constituents of the body which repair and build up the animal structure. Hence there will be emaciation and organic lesions of many forms. When the animal body becomes so much depraved by the irritability of its capillary system, and the deposition of improperly selected materials in the tissues, it is not wonderful, though the person be removed to a position more salubrious and more favourable for the body retaining its nervous powers, months may pass before the organs be completely recovered and their capillaries invigorated.

The portion of the earth on which an animal stands is generally liable to severe fluctuations in its electric tension. That division of the earth which is situated between the tropics is subjected to these changes to a greater degree than the other great divisions of the earth. It has been stated already, that these electric changes will be greatest in those situations in which there is the greatest amount of evaporation. It is well known to almost every medical man who has laboured in hot climates that the healthy season is the dry season, and that the rainy, or rather a short time after it, is the sickly season. There are certain situations which are so affected as to be notoriously unhealthy nearly all the year round. India probably presents a larger number of situations of this character than any other portion of the world. Mr. Annesley, in his work on the Diseases of India,* gives a very comprehensive and accurate view of the disease-begetting portions of the Indian continent. A reviewer of this work states that Mr. A. traces the cause of the diseases of warm climates "chiefly to the operation of solar heat on the soil when more or less moistened with water, so as to produce the exhalations known under the name of *miasma* or *malaria*." He states that "the view of this subject which Mr. Annesley takes, though in imitation of that of Lind, is, however, more complete, and derived from a more comprehensive and, perhaps, more accurate survey of the surface of the globe. The different sources of miasma or malaria, he refers to the following heads:—1st, marsh lands, and the low grounds along the banks and at the mouths of rivers; 2nd, the low, dense, luxuriant copsewood, called jungles in the East; 3rd, forests situate in valleys; 4th, rice-grounds; 5th, canals and ditches, pools and lagoons.

"The situations most favourable for the formation of this product, he shows to be the low grounds in the bottom of valleys, and along the banks or near the mouths of rivers, whether they be alluvial islands, extensive and multiplied interamnal deltas, or mere marshy tracts; and this character he applies especially

* Edin. Med. and Surg. Journal, 1828, p. 422.

to the tracts contiguous to the Jumna, the Burrompooter, the Irrawaddy, and other rivers of India.*

. . . . . . "The facts given in this survey afford an ample confirmation of the general accuracy of the doctrine which ascribes the predominant maladies to the physical peculiarities of the country. Thus it appears from the official returns made to the Medical Board of the Bengal Presidency, for a series of five years, that, in that province, which abounds throughout with materials for malaria, fever is most frequent in the rainy and hot seasons; that dysentery and diarrhœa are more prevalent during the rainy and cold seasons; and that hepatitis and cholera are oftener met with in the hot season. The banks of the Hoogley and the adjoining district are very low, and have long been known to be particularly insalubrious; and in this district, and the contiguous one of Jessore, which are almost submerged during the rainy season, fever and dysentery prevail to an extreme. The sickliness of Diamond Harbour on the Hoogley is well known. Moorshedabad, the native capital of Bengal, a city of 200,000 inhabitants, is very unhealthy even to the natives; and for this, its situation on a low level soil, on both sides of the Cossimbazar, the most sacred branch of the Ganges, surrounded by jungle and swampy plains, sufficiently accounts. In Gundwana, as in other parts where thick jungle and swamps abound, bilious remittent fever and dysentery are frequent among Europeans; and agues, ulcers of the legs, diarrhœa, and rheumatism, among the Sepoys and natives. Cuttach, in the province of Orissa, which is much covered with wood and dense jungles, and

* Edin. Med. and Surg. Journal, 1828, p. 427.

intersected with streams, and during spring tides almost inundated with sea water, is a remarkable illustration of the general principles stated.

. . . . . . "In the Mysore, the island of Seringapatam, formed by the separation and re-union of the Cavery, though upwards of 2,000 feet above the level of the sea, is, nevertheless, so circumstanced, that it possesses many of the conditions necessary to an insalubrious climate. Lying in a deep valley, and consisting of a rich, black, alluvial soil, through which, during the monsoon, water percolates freely from the river, as the whole of the small island is appropriated to wet cultivation, it forms for miles an uninterrupted swamp, from which, previous to and during the south-west monsoon, the noxious exhalations are wafted in abundance to the inhabited place. It is on this account apparently that the season which terminates with the north-east, and commences with the north-west monsoon, is mentioned in an able official report as the most fatal at Seringapatam.*

. . . . . . "Much the same character applies to Rangoon, on one of the mouths of the Irrawaddy, on a low swampy delta, which is, at one period of the year, either entirely inundated, or an extensive marshy beach."

The principles above alluded to are, that malaria or miasm is the cause of disease in warm climates. The regions there referred to are the most favourable for the process of evaporation, and, as a consequence of the circumstance of the periodical absence of rain, and the alternation of long-continued drought, there must be at these times a great

* Edin. Med. and Surg. Journal, 1828, p. 428.

change in the electric tension of the soil. When the soil has for a long time been continuously operated on by solar heat, and become thoroughly dry, and when there is no evaporation, and no dew, then this district will become in a high degree positively electrified: and this ought to be the healthy season. A large amount of the instrumentality which causes disease depends on the physical peculiarity of those portions of the earth which are found unhealthy. All those countries which are signalized as the haunts of pestilential and other diseases are, in topographical character, as nearly alike as possible in every part of the world. It is a general rule, that those situations which are high and dry are healthy; and, on the contrary, that those which are low, damp, and swampy are unhealthy. Dr. Baikie states that remittent fever in Africa, as elsewhere, is usually the result of exposure to malarious influences, and it is most prevalent and most fatal in low damp situations, where the poison exists in the greatest abundance. In high and dry situations it is comparatively rare, or altogether unknown. The hilly and high situations are free from the unhealthiness of the regions below, but it is because they are dry that the peculiarity of healthiness is attributed to them. Mr. Parkin, in his work on "*The Remote Cause of Epidemic*" disease (page 16), although with no view to establish the same position intended by this treatise, relates some facts of the same kind as Mr. Baikie does.

"Again, it has frequently happened, during the prevalence of the epidemic cholera in India, that certain corps on march have encamped for the night in a particular spot—the men being at the time free from all disease—before the morning numbers have been attacked with cholera, and many have died. Either from design or accident, the camp has been broken up, and the healthy and the sick removed to another locality; *this is no sooner done than the disease ceases.* Thus, a light infantry regiment, returning from the Deccan war to Bombay, was attacked by the epidemic at its bivouac, when an havildar stated to the commandant, that *there was no cholera a few hundred yards further on, beyond the Nullah;* the camp, therefore, was broken up, and the regiment, *carrying the sick along with it,* marched beyond the morbific boundary: *and the plague was stayed.* We are also informed by Dr. Henderson, that the 13th regiment of infantry, to which he was attached, together with the 38th and 48th, encamped on a low marshy spot, near to Patnago, in 1825; in the morning, one officer was attacked with cholera, and in twenty-four hours twenty men were carried off. On the following day, the corps removed *to a higher ground,* a mile and a half off: *and,* from this time, *no more cases of cholera were observed* in the army. An example of the same kind, but on a larger scale, was afforded by the army under the command of the Marquis of Hastings: which was attacked with the cholera, in Bundlekund, during the first year of the prevalence of the epidemic. This division of the grand army had encamped on the banks of the Sinde, immediately after which the disease appeared; commencing, however, in its usual insidious manner, by attacking only the lowest orders of the camp-followers. But in a few days, and as it were in an instant, the disease burst forth with irresistible violence.—'Unsubjected to the laws of contact and proximity of situation,' to quote the writer of the Bengal report, 'which have been observed to mark and retard the course of other pestilences, it surpassed the plague in the width of its range, and outstripped the most fatal disease hitherto seen, in the destructive rapidity of its progress. In the course of a week it had overspread every part of the camp, sparing neither sex nor age, in the undistinguishing virulence of its attacks; the old and the young, the European and the Native, fighting-men and camp-followers, were alike subjected to its visits; and all equally sunk, in a few hours, under its most powerful grasp. It was then wisely resolved by the commander-in-chief to change the encampment, *in search of a purer air and a healthier soil* (the reasons assigned for the measure in the official report); and although the line of march was covered with the dead and dying,—men dropping from their horses or falling while marching in the ranks, as if struck by a cannon ball,—they succeeded, after a few intermediate halts, in reaching, on the 19th, *the high and dry banks* of the Betwah, at Erich; *where they almost immediately got rid of the disease:* for not a single severe case occurred after the 22nd."

It is not said whether the situation, "a few hundred yards further on, beyond the Nullah," to which the light infantry resorted, was higher or drier than the place where they had just suffered so much from cholera; but we have reason to infer that it was so, as the regiment to which Dr. Henderson was attached, and the army under the Marquis of Hastings, are represented as finding, that on being placed on higher and drier, and consequently more positive ground, the pestilence was immediately stayed. The reason why men dropped down on the march may be their having been, and still being, exposed to the abstracting influence of a highly negative soil, whilst they were expending a large amount of nervous power in their efforts on the march.

In the above narrative it is represented, that it was only required that the army remove a few yards farther up, to escape the pestilence which was committing such devastations among them. Surely the miasm is very tenacious of a low damp situation, as it is found that whenever the army removed to a high and dry position, the pestilence was immediately stayed. If the army had ascended by a flight of steps to a platform a few yards higher up, provided it were perfectly dry, with the pestiferous locality close below it, it would have been equally secure as at a distance of miles.

This *miasm* must have distinct gravity when it cannot ascend a few feet over a dry surface; and it evidently has no affinity for dry regions in any part of the world, as it makes no display of its virulence in dry situations. It is mentioned in the above narration, that the lowest class, the most debilitated, were the first victims to the disease. This arose from the little nervous power which they had to spare, as it was taken from them by the good conducting power of the low evaporating locality. If the army had known to have encamped at first on the high and dry ground, the sickness and loss might have been averted, as there they would have avoided the obstructing power of a low state of electric tension, which exacts so powerfully from the nervous forces.

In the review (*Ed. Med. and Surg. Journal*, for 1825)* of the report of the epidemic cholera of Asia, it is stated, "That cholera appeared in the most northerly villages of the Zillah of Nellore about the 2nd of August, manifested itself at Ongole on the 14th; at the town of Nellore, from which the Zillah is named, on the 20th September; and before the 5th of October it had reached its southern extremity. In twelve days it travelled thirty-two miles; in the next twenty-seven days it travelled eighty more; and in two months from the date of its commencement, it traversed the whole Zillah, except its two south-west divisions, which entirely escaped the visitation. These parts which are the *most elevated* of the Zillah are populous and much frequented by merchants; and the disease was observed to be either less fatal or less common in its whole western frontier, contiguous to the hills."

In the above extract it is not mentioned what was the state of the weather during the prevalence of cholera, nor what course it pursued, whether in plains or valleys, or along the course of rivers. There is not such a particular description of the topography of the country as to allow correct conclusions to be made regarding the wetness or dryness of the localities referred to. Indeed, the most elevated positions are pointed out as those which altogether escaped the pestilence, although they were the most populous and most frequented by merchants. The merchants, in the prosecution of their business, must of necessity have proceeded from town to town; and, if it had been possible to convey the disease by contagion, there was, by

* Page 183.

mercantile correspondence, every facility for spreading it. The reason why those who occupied the Eastern frontier contiguous to the hills suffered more than those who were most elevated, was that the lower position in which they were placed caused them to be on soil which contained more water, and, consequently, they were exposed to the effects of evaporation.

Irrespective altogether of altitude, dryness of the surface of the earth is conducive to health, even in localities where pestilential diseases prevail. Thus, those places with this unfortunate peculiarity lose it completely when a dry wind passes over them, as then the diseases disappear and the region is found healthy.

In his Dictionary, in the article on Septic Pestilence,* Dr. Copland remarks that "the winds have no mean influences in the development and spread of plague, especially in the East. At Constantinople, the north wind, called the Tramontana, which is dry and cool, prevents or arrests the progress of the distemper; whilst the Sirocco, or south wind, which is both warm and moist, favours the development and spread of the malady. High winds, especially when they are dry, remarkably diminish the infectious disposition, and restrain and arrest the propagation of the disease, chiefly by dissipating and diluting the miasms proceeding from the infected, and giving rise to freer ventilation in crowded streets and houses. The salutary effects generally derived from placing infected troops or communities in tents, upon a dry, aired, or healthy soil, proceed chiefly from the readiness with which the winds pass under the

* Vol. iii. p. 219.

tents and dissipate morbid emanations, or dilute them, so as to render them inoperative. Dry winds also render the human constitution less susceptible of contagion. Thus it has repeatedly been observed that the Harmattan, a remarkably dry north-east wind, occasionally blowing for several days on the west coast of Africa, suspends the infection of small-pox, and that even inoculation of that disease is generally inoperative whilst it blows."

Dr. Copland is a firm believer in the doctrine of contagion, and also in the existence and operation of malaria in those regions which are supposed to favour its production, and the facts found in his writings, which support the views here advocated, are only incidentally favourable to them. In further support of the position, that dryness is favourable to health, Dr. Copland mentions that "the plague is very rarely introduced in Arabia; the passage across the desert, and the state of the climate in many parts of the country, being unfavourable to its development and spread of its contagion; and it is generally admitted that the pestilence has never appeared there unless when imported." According to the Doctor's principles, as a contagionist, he believes that plague cannot be found existing anywhere without being imported. Destitute though Arabia be, as a rule, it is too much to expect that rain never falls to such an extent as now and then to give rise to the evaporation, and consequent humidity, which is represented as so highly necessary for the development of the contagious seminium; yet is it free from this disease? The Arabs are proverbial for their erratic habits, and cannot fail to have, in their wanderings, been sufficiently near patients labouring under plague, frequently to carry off the contagious principle, if such an agent exists.

Plague has frequently raged in the countries around Arabia. Both Syria and Egypt suffer frequently and severely from the inroads of this disease; yet, notwithstanding its close proximity, Arabia, as a rule, enjoys a happy immunity from pestilential diseases; and all this from the dry condition of the soil, and the general absence of humidity of the air. Syria and Egypt, on the contrary, are the hotbeds of pestilential diseases, and have frequently been invaded by the plague. The frequency, as well as the severity, of these invasions is attributed to the occasional wetness of those countries, and consequent humidity of the air. Dr. Copland points this out very clearly, in a paragraph closely preceding the one quoted above, and the author more readily quotes from the Doctor, as he is a sanguine contagionist:* "It is, however, not so much the temperature as the *humidity* of the air which favours the extension of this pestilence, and the former may be said to be operative only when it is conjoined with great humidity. This is evinced at Constantinople, where the air is very humid in spring and summer, owing to the influence of the adjoining seas, the extensive forests, and high ranges of mountains. In Lower Egypt and Syria, especially in places near the coast, the winter and spring are humid and rainy, and the atmosphere close and still; and although the range of temperature is not high, still the close and moist air favours the accumulation of the emanations proceeding from sporadic cases of the pestilence, or from clothes

* Vol. iii. p. 19.

retaining these emanations, and renders those exposed to them more susceptible of their influence. When, however, the atmosphere becomes dry, whatever may be the range of temperature, the pestilential miasm loses much of its power, and the population, or those exposed to it, much of their susceptibility. It is, therefore, chiefly owing to the combination of heat with humidity that the former is influential in the diffusion of this pestilence."

The Doctor here carefully points out that temperature in itself has little effect in propagating plague, but that it is humidity of the air which favours the propagation of the pestilence, as the malady is very much mitigated, or disappears altogether, as soon as the air becomes dry.

It is, principally, in so far as the humidity of the air depends on evaporation from a wet soil, that, according to the principles here advocated, it can operate prejudicially in causing disease; that is to say, that the humidity of the air is an evidence of evaporation from the soil, thereby disturbing the electrical relations of the earth and the objects on its surface. Air, however, when it is saturated with moisture, or near the point of saturation, is found to be very injurious to the animal body, although it is not produced by evaporation from the soil over which it is found. This is demonstrated in some of those countries whose shores are washed by the waters of the Mediterranean sea. Italy is one of those countries which are distinguished by this unfortunate peculiarity. During the summer, Italy is nearly as hot as the East or West Indies, and during this season the ground and the objects on it are thoroughly dried. This, according to the principles here advocated, will produce in the earth and the objects thereon, a highly positive condition of electric tension; and the animals placed on it will enjoy good health and corporeal vigour.

There is a wind which blows from the south about the end of summer or early autumn, called the Sirocco, which affects Italy, in common with other countries in the same neighbourhood. According to a writer on the causes of disease in this country —"The Sirocco appears to suspend, exhaust, or paralyse the nervous energy of the body, and the sensorial vigour of the mind, both of which fall prostrate beneath the flood of enervating steam engendered by the aërial current sweeping over burning sands and evaporating seas." This wind is so saturated with moisture, that the vapour is condensed on objects which are found sufficiently cold for the purpose of condensation, as so long as it continues, the people who are exposed to its effects are extremely unhealthy. Dr. Hennen states that* "the walls of houses, stone floors, and pavements invariably become moist when the Sirocco blows. I have seen the stone floors at Corfu absolutely wet without any rain having fallen; and gentlemen, who have made hygrometrical experiments, state to me, that the instrument has frequently fallen from ten to twenty degrees during the prevalence of this wind." "That the southerly wind in general, and the modifications of it in particular, are unfavourable to the health and spirits of man, is an opinion upon which all classes of persons with whom I have con-

* Sketches of the Medical Topography of Corfu.

versed throughout the Mediterranean are unanimous. . . . . . I have scarcely ever met an individual who was not more or less sensible to these effects; some, who have felt them but slightly on their first arrival, have become exquisitely sensible after some time; many can foretell the approach of a Sirocco some hours before it begins to blow, by the peculiarities of their feelings; and there are few indeed who cannot at once decide that this wind has commenced, without making any reference to external objects; but it is by the sick and the weakly convalescent that its depressing effects are most severely experienced." "Whether all the lower animals feel the relaxing effect of the Sirocco wind I know not; horses certainly do, for they sweat sooner, and are more languid, than at other times; but on inanimate nature its effects are very obvious, and have repeatedly come under my notice in various parts of the Mediterranean."

It is not possible to conceive that the mischievous influences of the wind can depend on any malarious emanations from marshes, from decaying animal or vegetable matter, or from pestiferous gaseous exhalations; as there can be none in the region whence it springs. Lybia is arid and dry, and there are no decomposing agencies in the sea over which the wind blows, to produce the "all-prevailing" plague-producing miasm. There are no difficulties in applying the principles put forth in this treatise, as in the author's opinion they are rational and satisfactory. The Italians, during the hot months of early summer, are exposed to the bracing instrumentality of dry air and a dry soil; and so long as the air and soil remain dry, they will be comparatively positively electrified, and in this condition they will have little abstracting power on the animal on this soil and in this air. No sooner, however, does the time arrive when the Sirocco is expected to blow, and before it is fairly set in, than its effects are experienced by the susceptible. This is felt by those individuals before the aërial enemy has attained any force. Scarcely have the winds begun to move from the direction whence they blow, before their effects are perceptible. The wind has already a supply of moisture which has as yet only a partially abstracting power, but it is sufficiently powerful to weaken the already weak, to abstract nervous power from those whose nervous energies are reduced by disease, as well as those who were never strong. It is when the full-freighted wind sheds over the people its dewy damp depositions, that the healthy and strong experience the discomfort, the languor, and debility produced by this pestiferous wind, which causes the feeble to become feebler, and the miserable to be more miserable.

The writer continues to remark,—"Yesterday, the Sirocco—'Auster's sultry breath"—steamed over Naples, depressing the animal spirits and the vital energies to the lowest ebb.* It is impossible to convey in words any adequate idea of the sedative effects of this wind on mind as well as body. I tried to respire with freedom on the roof of the Victoria—on the Chiaga—the Mole—the Chiatomone; but found no relief from the nervous depression and muscular languor induced by this mephitic composition of rarefied air and aqueous exhalation. I hired a calessino and drove round the

* Change of Air, or the Pursuit of Health, p. 207.

promontory of Posilipo—and afterwards ascending to the airy castle of St. Elms, wandered through the beautiful church of St. Martino—but all in vain! From lassitude of body and dejection of mind there was no escape, while this accursed blast prevailed."

No amount of excitement could drive off the languor and nervous depression experienced by this observer.

In the effects produced on the animal system by the Sirocco, we have, in an aggravated form, what usually takes place in marshy districts in hot climates. There is the moist and damp atmosphere; without any of those supposed agencies which operate mischievously, without decomposing animal and vegetable matter. The impossibility of the presence of decomposing operations here, gives an opportunity of judging of the exclusive influence of aqueous vapour in producing disease. Therefore when the mere moisture can work so powerfully for evil in Italy, and those other countries which are operated on by this wind, apart from all other agencies, the conclusion is irresistible, that the instrumentality of mere moisture in producing disease has not been fully appreciated by those whose attention has been directed to discover the remote cause of disease.

Viewing the nervous power and the electric as one and the same, and the moisture as an active conducting agent, there are, in the circumstances of the Italians and the Sirocco winds, rational considerations for accounting for the unfavourable effects produced on the people during the prevalence of those winds. The moisture, being an excellent electro-conducting agent, acts upon the nervous system, abstracting from it its power. This is demonstrated by the lassitude and feebleness which speedily occur at the onset of the moisture; and the abstracting influence being continued, the nervous power is so far reduced, as to be unable to continue vigorously the vital operation. Thence will result vitiation of the secretions and of the sanguineous fluid, and the diseases consequent thereon. Italy, with a cloudless sky, in early summer, is subjected to the burning rays of a nearly vertical sun, which dries up the soil, and puts it in a highly positive electrical condition. The soil in such circumstances will impart electricity to people, rather than abstract it from them, and they will be in a highly favourable condition, in so far as their electric state is concerned. The high temperature of the season induces the people to be proportionally lightly clad, and the moist wind, being also of a comparatively high temperature, does not cause them to clothe themselves with good non-conducting vestments. They are consequently exposed to the good conducting power of the moisture, and hence their sufferings. If the people who are exposed to this damp wind had any means of shutting it out, they would escape its bad effects on the nervous system. A writer in the *Medico-Chirurgical Review*, in reviewing a work by Dr. Hennen, remarks, that "it is fortunate that man can mitigate, in some degree, the effects of the Sirocco, by shutting the doors and windows, and confining himself to the house. Dr. Hennen felt great relief by keeping a large wood fire constantly burning in his room—though to others it appeared insupportable."*

* Medico-Chirurgical Review, Dec. 1830, p. 99.

The experience of Dr. Hennen, with a fire in his room, was as nearly as possible an exclusion of the damp air, and was just what might *a priori* be expected on these principles. The shutting of himself in his room, supplied with a good fire, would not shut out the moist air completely, as there would be wanted a large draft from without to supply the combustion within. The radiation from the fire, however, counteracted the influence of the moist air, and the room was kept dry, whilst all the inanimate objects outside and around him were moist and damp: all were exposed to the operation of the mischievous moisture, whilst he was in a great measure insulated and protected. He was in an electro-positive condition, whilst all around him were in an electro-negative state.

If these Sirocco winds were always to blow, the countries exposed to the constant humidity would not be habitable, as the air would be nearly in the same condition as that over the Pontine Fens. This effect is partially exhibited in marshy districts, in proportion to the amount and persistence of evaporation. In temperate regions, there is, in the neighbourhood of marshes, as in the fenny counties of England, a constant unhealthiness, developed in the form of mild intermittent fever; and in proportion as the countries with marshes approach the equator, the diseases become more severe. Besides the specific diseases which are produced by the operation of evaporating localities, the inhabitants generally suffer from their effects. To quote once again the words of Dr. Johnson, when speaking of the effects of the Italian malaria, "A glance at the inhabitants of malarious districts must convince even the most superficial observer, that the range of disorders produced by the poison of malaria is very extensive. The jaundiced complexion, the tumid abdomen, the stunted growth, the stupid countenance, the shortened life, attest that habitual exposure to malaria saps the energy of every bodily and mental function, and drags its victim to an early grave."

There is little doubt but that all the above described evils would be produced in an aggravated form in those countries which have been subjected to it, were the Sirocco to blow on them continuously. It is only because the Sirocco prevails for a short time, at a certain period of the year, that these localities are habitable, as there is a long interval between the periods of its occurrence.

"Pointed facts beyond number are related, both in France and Italy, of sickness being produced by the process of drying hemp; and we find in Lancisi, that numerous severe epidemics in the latter country have been traced to these operations, and among others, a noted one at Ferentino, and another at Orvieto, which lasted many years. In the former country, out of similarly numerous cases, severe intermittents broke out in the plain of Ferez in 1823, after October (a very rare occurrence), and were traced to this cause, and we have the assurance of M. Bourges that it is invariably pernicious; while he describes one very marked case, where fever occurred in a dry, sandy, and otherwise healthy and elevated situation, being regularly renewed with the steeping and drying of the hemp, and disappearing when this season was over."*

* Medico-Chirurgical Review, Jan. 1828, p. 20.

In the process of drying the hemp, there is instituted a process of evaporation in an otherwise dry locality; and in order to provide the electricity necessary to carry off this water, a draught is made on the whole neighbourhood, and the dry sandy plain is made less positive, and more negative, in point of electric provision. The animals within the power of this operation require to yield part of their electricity to assist the evaporation, and hence the diseases.

The above-described effects of the Sirocco are just an aggravated demonstration of the effects of the moisture in the air over marshes, in those countries where they exist. In the Sirocco there is a larger amount of moisture than what is generally found in the air over marshes, and, of course, the effect will be greater in proportion to the greater quantity of vapour in the air. Besides marshes, there are other causes of evaporation, unconnected with any appreciable amount of animal or vegetable life to produce either animal or vegetable decomposition, and which are found as injurious to life as the vicinity of marshes. Dr. Ferguson read a paper before the Royal Society of Edinburgh in January, 1820, on the Nature and Properties of the Marsh Poison, as known under the titles of Marsh Miasmata and Malaria, wherein the author endeavoured to prove from reference to the medical topography of different places in the south of Europe and the West Indies, that the universally received theories of aqueous and vegetable putrefaction, singly or combined, being the sources of the poison, were unfounded; that putrefaction, under any shape, had no effect in producing it;

that it never emanated from water in bulk, however putrid, but is the product of a highly advanced stage of the drying process, in absorbent soils, that had previously and recently been saturated with water. The illustrations were principally taken from the countries where the author had served during the previous twenty-five years, and exhibited a great variety of facts and observations in support of the opinions advanced.

The observations made by Dr. Ferguson, in so many countries, left on his mind the conviction that the cause of epidemic diseases depends on nothing but some effect produced by evaporation, irrespective altogether of decomposing animal or vegetable matter. What possible injurious effect could be produced on the soil, mischievous to the health by mere evaporation, unless it took something from the soil favourable to health? The most active efforts have been made to find some prejudicial agency, associated with the rising vapour, to account for the prevailing disease, which is so frequently connected with evaporation, but with no result. We are, therefore, shut up to examine what effects are produced by the mere operation of this process. It is known, then, that, in the process of evaporation, there is an immense abstraction of heat from every portion of soil on the earth which is thus operated on. Indeed, there can be no evaporation without heat, and the more evaporation there is in any given place, so will there be the greater abstraction of heat. This will cause the soil to be in a more negative electric condition than before the abstracting operation. It may be objected that, seeing that the heat which causes evaporation is wholly derived from the sun, all, therefore, are equally acted upon; the heat that raises the vapour will also heat the objects, animate and inanimate, in the same vicinity. There is no doubt but that the animals on the earth, in such localities, being acted on at the same time, will receive the like quantity of heat from the sun as the water in the soil which is raised by evaporation. In such circumstances, the animal will receive as much heat as the electricity which is withdrawn from them by the evaporating process. But, when the sun has gone down, the heat retained by the earth will radiate, and the evaporating process will go on, robbing the locality of its electricity, and changing it from a highly positive condition to one which is highly negative; and, if the animal continue in contact with the earth, the earth will withdraw electricity from the animal, and, if the abstraction be long continued, it may produce disease. It is on this account that, in times of prevailing epidemic disease, dangerous consequences result to those who expose themselves after sunset.

In an article in the *Edinburgh Medical Journal*, on the "African Remittent and Yellow Fevers," a fact is narrated on this subject by Dr. Baikie, who states that "Malaria is given off in greatest quantity during the night, and it appears to be dissipated, or more or less decomposed, by the direct action of the sun. Its poisonous properties, too, are most powerful at night, partly because of its greater abundance, and partly also, possibly, from the electrical condition of the human system, or of the atmosphere, at that time, rendering all morbific agencies to be more potent for ill during that season. It has been observed, especially in the East Indies, that in journeying by night through unhealthy jungles, travellers who sleep are almost always attacked, while those who keep awake generally escape the febrile influence—an additional and very direct proof of the diminished powers of vital resistance while the body is in a state of exhaustion or of repose." How unsatisfactory it is to be attributing such effects to a totally unknown and inappreciable agency!

It has been almost uniformly observed that the breaking up of original soil for the purpose of cultivation has been attended with ill-health to those who were exposed to its influence. A reviewer, in the *Medico-Chirurgical Review* for 1828, states that "it has often been noticed, in various parts of the world, that the breaking up, for the first time, of pasture lands, is attended with sickness. The evidence on this head is as abundant as it is unquestionable. Volney, Nash, and fifty other authorities, might be cited in proof." This sickness may be produced in the following manner:—The beaten and sodden condition of the surface before its being broken up, favours the running off of the water which falls on it, more especially where it has declivity to favour such a result. The water collects in hollows, forming pools, from which the evaporation is comparatively slow; and where the bare earth presents itself after the drying of the pools, the hard surface of the exposed earth will reflect the rays of the sun, which will thus disturb, to a comparatively small amount, the water of the subsoil. In this way rapid evaporation is prevented. When, on the contrary, the soil is turned up, in the process of cultivation—it may be a wet soil—there is an immensely greater surface presented to the solar influence, and from this surface there is carried up an increased amount of vapour, which, in changing its form from a liquid to a gas, abstracts a proportional amount of electricity. The reflection of the heat from the unbroken condition of the soil acts favourably on the animals in contact with such a region, whilst the absorption of this heat, by the open condition of the turned-up soil, facilitates the evaporation of the water it contains and the drawing off more effectually of the electricity from that portion of the earth and the objects resting on it. Sydenham would have been easily convinced that diseases arose from the disturbance of the electric relations of the earth, when he stated that he suspected that an invisible morbific agent sprang from the bowels of the earth.

Trees may so cover over or otherwise shade a portion of the earth as to prevent the action of the sun, and thereby hinder the production of evaporation. This is pointed out by Dr. Copland, in the article *on Endemic Influences.** "When low and moist grounds, and deep or rich soils, which have been covered by large trees, or by water, are cleared, or exposed to the action of a warm sun, especially in a hot country, they emit more noxious emanations than in their unreclaimed state; and they generally continue so to do, particularly during moist and warm weather, and after long-continued droughts following heavy rains, until they are completely brought under cultivation, and even for ages afterwards, in warm countries near the level of the ocean, or the sea-shore: circumstances which combine to make so many places

* Dictionary of Practical Medicine, vol. i. p. 758.

in the West and East Indies productive of disease. Rich soils, covered by large trees and other bulky vegetable productions, are thereby protected from the action of the sun; and the exhalations which are given off from them, during warm and moist states of the air, are confined by these productions to the situations which produce them. Dr. Rush states, that the endemic disorders of Pennsylvania were converted, by clearing the soil, from intermittents and mild remittents, to bilious and malignant remittents and destructive epidemics; and that it was not until the soil had been subjected to cultivation for a number of years, that a tolerable degree of healthiness was procured. The district of Bresse, in the Lyonnais, when well wooded, was comparatively healthy; but now, deprived of its woods, the low and wet soils being exposed more to the action of the sun, the exhalations from these, and from its numerous marshes and stagnant pools, are no longer confined by surrounding forest trees, and, consequently, endemic diseases of a severe character are very prevalent. Similar instances are to be found in the works of Devèze, Monfalcon, and Bailly."

Although Dr. Copland is a firm believer in the existence of a contagious influence as a cause of disease, yet he admits the reality and instrumentality of noxious emanations, as operating unfavourably on the human system. These emanations are more copiously given off when a primitive surface is exposed to the rays of the sun. The presence of the trees prevents the sun from beating on the soil, and so heating it as to dry up the moisture. Another circumstance is, that the soil under the original surface is generally composed of leaves and other vegetable débris, which, being bad conductors, do not absorb the transient rays that might pass through the intervals between the separate trees. When trees are cut down, it is generally for the purpose of cultivating the soil, and the breaking up of it presents an incalculably larger surface to be acted upon by the sun's rays. These rays acting on the moisture will cause a large amount of evaporation, where formerly there was comparatively none.

Other examples of increased evaporation and consequent prevailing sickness are frequently produced by the exposure of the bottom of a lake, mill-dam, &c. Dr. Macculloch states, that while "pools retain a considerable depth of water, or whenever their banks are steep, no malaria is produced, but that it appears in reverse cases, or, either on the diminution of the water in depth, or on its retiring from the shores. The same facts, I should observe, have often also been noticed in the West Indies; while a very strong case, illustrating this particular cause, is stated by Senac, in France, where, in a town previously unaffected by fevers, a violent epidemic was produced in consequence of an unusual evaporation which exposed a large portion of the bottom of a lake."* So long as the lake was filled with water, no mischievous results took place, water in bulk being a good conductor of heat, and giving off comparatively little by radiation; but as soon as the bottom is presented to the influence of the rays of the sun, the material forming it will be raised to a very high temperature, in consequence of which the water in contact with it will be suddenly raised into vapour, and with the vapour, there will

* Dr. Macculloch on Malaria, p. 98.

be carried away the electricity surrounding the portion of the soil thus circumstanced.

The evil effects of this are illustrated in many places and in many different degrees. A most striking instance of a thoroughly formed marsh, and its deleterious effects on animal life, is quoted by Dr. Watson.

"The late Bishop Heber, in his *Narrative of a Journey through the Upper Provinces of India*, gives the following striking picture of the influence of the malaria in that part of the world. It seems to be alike pestiferous to man and beast.

"'I asked Mr. Boulderson if it were true that the monkeys forsook these woods during the unwholesome months. He answered that not the monkeys only, but everything which has the breath of life, instinctively deserts them from the beginning of April to October. The tigers go up to the hills; the antelopes and wild hogs make incursions into the cultivated plains; and those persons, such as dâk-bearers or military officers, who are obliged to traverse the forest in the intervening months, agree that not so much as a bird can be heard or seen in the frightful solitude. Yet during the time of the heaviest rains, while the water falls in torrents, and the cloudy sky tends to prevent evaporation from the ground, the forest may be passed with tolerable safety. *It is in the extreme heat, and immediately after the rains have ceased*, in May, the latter end of August, and the early part of September, *that it is most deadly*. In October, the animals return. By the latter end of that month, the wood-cutters and the cow-men again venture, though cautiously. From the middle of November to March troops pass and repass, and, with common precaution, no risk is usually apprehended.' "

As in other places, it is not when the swamp is covered with water that its deleterious effects are produced. It is when the water above the surface is dried up, and the soil left saturated with moisture, that the deadly effects are produced. It is then that the evaporation is most active, drawing most plentifully the water from the soil, and, along with it, the electricity with which the soil is charged. It is when this active evaporation is going on that even the inferior animals instinctively keep back from the dangerous swamp, appropriately called dismal.

Dr. Macculloch states that mill-dams are injurious from the marshy nature of their margins. He states that about the iron-districts of Glamorganshire there are numerous large mill-dams for the supply of machinery, "and there is not one of these in the lower grounds which is not notoriously attended by the ill-health of all the immediate residents and visitants," consisting in various diseases. Besides the dams, there is here a disturbing element which ought to be taken into account, viz., the iron found among the minerals of the district. The iron, having a strong attraction for the electric fluid, may draw it from the surface, and thus produce there a negative electric condition, besides that which is produced by speedy and copious evaporation.

The mischievous influence of mill-dams seems to arise from the alternate filling and emptying of their contents. From early morning, when the work begins, the water is gradually drawn from the fountains; and, if it cover a large surface, and withal not deep, there will be a large wetted surface exposed to the heat of the sun, and the evaporation will be active in proportion to the heat, and extensive in proportion to the surface exposed. A mill-dam may, in certain circumstances, represent a swamp. The swamp may be so covered with water that comparatively little evaporation will take place, as in the case of the dam when filled; but as soon as the water is to a certain extent dried up, and the bottom of the swamp exposed to the solar beams, then will be produced the same effects—modified, however, by climate—as are produced by the drying of the bottom of the dam. The Reviewer of Dr. Macculloch's work states that "a swamp may be too wet to produce miasmata, and a certain drainage may just bring it into that state which is peculiarly favourable for the extrication of the unknown poison. This appears to have been the case with the Campagna di Roma, as far as the facts can be ascertained by comparing the different accounts of Italian writers. The most pointed instance, however, is that of the marsh of Chartreuse, near Bourdeaux. A succession of bad fevers, before unknown, showed themselves immediately after the drainage of the above marsh, first in that part of Bourdeaux which lay nearest to the land reformed, and, afterwards, through the whole town. These fevers lasted for many years, and proved so severe in 1805 that twelve thousand people were affected, three thousand of whom died in five months."* So soon, however, as the evaporation is over and the land completely dried, the place would become perfectly healthy. It has been almost uniformly found in all those places where swamps existed, that as soon as the land is sufficiently dried, the insalubrity disappears.

* Medico-Chirurgical Review for 1828, p. 19.

CHAPTER III.

ON THE CAUSE OF THE DISEASES WHICH ARISE IN SITUATIONS WHERE THERE ARE NO MARSHES.

The insalubrity of those parts, in hot countries where the sea-coast and rivulets are covered with mangrove vegetations, has been particularly observed. This may be produced by the facilities arising from the peculiarity in the nature and structure of these bushes. The growth is speedy and luxuriant, and the decay rapid and incomplete, as a new plant is engrafted into the stem of the old, which maintains an interminable succession of additional plants, exhibiting, in many situations, an expansion of rank and, at the same time, beautiful verdure.

The underlying accumulated vegetable débris is somewhat in the condition of a sponge, absorbing and retaining at every return of the tide a large quantity of sea-water, which, being acted upon by concentrated solar heat, and a high temperature being produced under the abundant foliage, the evaporation is both speedy and copious. The unfavourable peculiarity in localities thus situated is, in the author's opinion, produced in the following manner:—There is in the circumstances of the mangrove plants, a continual and abundant evaporation, establishing a constant drain of electric fluid from the district within its influence, which makes it negatively electrified; and the animal being always positive, from the electricity continually evolved by the vital processes, suffers loss of electricity, because of the tendency in the fluid always to produce an equilibrium; the animal suffering in proportion to the amount withdrawn, and to the integrity of the operation of the vital processes. In an open and inland country, on the contrary, which is destitute of marshes and jungle, the humidity is only occasional and short-continued, and in proportion to the amount of rain and the facilities for evaporation. In place of a constant insalubrity, as in situations and circumstances such as those of the mangrove plants, there is merely a casual and temporary insalubrity. In marshes and near jungle there is a constant unhealthiness; and it will be found that this mischievous peculiarity is in proportion to the warmth of the position in which the marsh is placed, and according to the persistance of the evaporation. On this principle, it ought to follow that cases of ague and other diseases, which occur near marshes, will be mild or severe, just in proportion to the amount of evaporation, but seldom so virulent as in the situations occupied by mangrove plants. A marsh is most favourable for evaporation when the water scarcely covers the soil. The cause is obvious: the soil and vegetables become much more heated than water in a large quantity together, as in a lake, or as it exists in the sea; the soil and vegetables heat the water to a much greater temperature, and thus is produced ready evaporation. There might be cited, from many writers on pestilential diseases in tropical countries, examples of wide-spread disease, and, at the same time, an absence of every other apparent instrumentality. There was no vegetable or animal decomposition, or any other source of insalubrious effluvia, on mere sandy plains, but the speedy evaporation of the recently fallen rains, and the presence of a severe pestilential scourge.

There is an extensive sandy plain at Gibraltar, called the Neutral Ground. This is partly by nature dry and barren, and art having added to the barrenness, it would now be as easy, according to Mr. Nash, to find organic growth on a sheet of paper, as there.

Dr. Hennen, in a work entitled *Sketches of the Medical Topography of the Mediterranean, comprising an account of Gibraltar, the Ionian Isles, and Malta, &c.*, gives a description of the above-mentioned Neutral Ground, which we will transcribe. "In winter the rain-water forms numerous and extensive pools, which continue during the spring months. These pools are only dried up completely by the summer heats; but there is one near the high road which is never completely dry. Besides these adventitious depositions of moisture, there are numerous internal sources of permanent supply at the Neutral Ground. I have been led particularly to examine this spot, in consequence of the assertion that no source whatever of marsh miasmata existed at Gibraltar. If, by this assertion, it is meant that *no morasses* at present exist, I perfectly concur with it; but I can go no further, because, under the present head, I have indicated numerous sources of aqueous exhalations, and I am about to point out others of a still more extensive nature. Indeed, the most superficial observer could scarcely ride over the Neutral Ground without perceiving many external evidences of under-ground moisture. The '*Arundo Phragmites*,' the infallible test, grows, even now, in great luxuriance on several of the banks which surround the gardens: it is only necessary to thrust the reeds into the sand and they soon take root. It appears that this plant was formerly much more common and more extensive, for in the different histories of the siege, we frequently meet with accounts of the reeds being set on fire, &c.; but the fact does not rest on this species of evidence, or on external appearances,—the auger and the shovel prove it completely." *

Mr. Nash represents the above-described plains as being destitute alike of vegetation and of moisture, and states that to this place no commanding officer will send a "new arrival," knowing that, if he does, the man will be reported on the sick list next day; for until the men be seasoned there will be great risk in their spending a night in such a locality. He seems to have made a very superficial examination of this unwholesome situation, as Dr. Hennen found it for the most part of the year to be a perfect bog, or rather sponge, and, at its driest time, capable of supporting an aqueous plant. The question naturally occurs, if no commanding officer will send a "new arrival" to this station, as he is sure that he will be reported sick next day, why have the station there at all? When all past experience proves that the station is notoriously insalubrious, and that many lives have been known

* Page 22.

to have been sacrificed, is it imperative that Her Majesty's service requires a station in this exact spot; and is it not possible to procure a residence for the troops, other than that which experience and observation have pointed out as unwholesome and pestiferous?

For the purpose of still farther showing that a locality may be insalubrious without having any of the associations which are considered necessary for the production of malaria, Mr. Nash cites another place. He states that "the neighbourhood of Lisbon gives me another example. About two miles to the north, I think, there is a small rivulet, the Alentijo Rio; this, in the summer, is dry, being scarcely more than a draining stream; the valley is dry enough, and the bed of the rivulet is bare and stony; yet the inhabitants will never pass along the valley during autumn, experience having taught them that miasm abounds." Although this rivulet's bed may be bare and stony, yet, as in the above-mentioned Neutral Ground, there may be, not far under the surface, a sufficient quantity of water to yield a large supply of moisture, and greatly more than when the course of the stream was filled with water. The dry surface of the ground forming the course of the stream will become much heated by the direct rays of the sun, and the reflection of the rays from the sides of the valley will still farther increase the heat; causing a great concentration of this element in the valley, and producing active and copious evaporation, and leaving the locality in a highly negative electric condition. Consequently, people passing along the valley will, especially at night, lose animal electricity by the good conducting power of the ground on which they walked.

Dr. Watson mentions several places where the British army encamped during the late war, which were particularly insalubrious, although the surface was perfectly dry, and free from all vegetation, either living or dead. Although the surface was dry, there was water a few inches under the surface. The doctor states that "In August, 1794, after a very hot and dry summer, our army in Holland encamped at Rosendaal and Oosterhout. The soil, in both places, was a level plain of sand, with a perfectly dry surface, where no vegetation existed, or *could* exist, but stunted heath plants. It was universally percolated, to within a few inches of the surface, with water which, so far from being putrid, was perfectly potable. Here fevers of the intermittent and remittent type appeared among the troops in great abundance. It is interesting to observe that the soil in Walcheren is precisely similar. Sir Gilbert Blane describes it as consisting 'of a fine white sand, known in the eastern counties of England by the name of silt, and about a third part of clay.' It was after a hot and dry summer, also, that the British army suffered in that island from the endemic fever, which Dr. Ferguson speaks of as 'being almost unprecedented in the annals of warfare.'

"In the year 1809, several regiments of our army in Spain took up an encampment in a hilly ravine which had lately been a water-course. Pools of water still remained here and there among the rocks, so pure that the soldiers were anxious to bivouack near them for the sake of using the water.

Several of the men were seized with violent remitting fever before they could move from the bivouack the next morning. 'Till then (says Dr. Ferguson) it had always been believed amongst us that vegetable putrefaction (the humid decay of vegetables) was essential to the production of pestiferous miasmata; but in the instance of the half-dried ravine before us, from the stony bed of which (as soil never could lie for the torrents) the very existence even of vegetation was impossible, it proved as pestiferous as the bed of a fen.'

"After the battle of Talavera, the army retreated along the course of the Guadiana river, into the plains of Estremadura. The country was so arid and dry for want of rain, that the Guadiana itself, and all the smaller streams, had in fact *ceased to be streams*, and were no more than lines of detached pools in the courses that had formerly been rivers. The troops there 'suffered from remittent fevers of such destructive malignity, that the enemy, and all Europe, believed that the British host was extirpated.'"

There are here very good provisions for evaporation. The sand, being composed of pulverised mineral bodies, formed a good conductor of electricity. Whilst the sun shone on the sand, the water under it would become heated, and evaporation would be actively produced, and notwithstanding the evaporation during the day, the soldiers would receive little injury whilst the sun shone, as then the heat of his rays would compensate for the electricity withdrawn from the body. At night, however, when the soldier lay on his blanket on the sand, the sand, being no longer heated by the sun, exacts heat from the poor soldier, who is thus operated on by two unfavourable agencies, the water as well as the sand. He is operated upon by this abstracting power, when the system can least afford to spare the electricity which is produced by internal elimination. The digestion is less active, the respiration is slower, and all the organs of assimilation are in the most languid condition, yielding little electricity to the nervous system, which, being shorn of some of its power, is unable vigorously to continue the operations of secretion and assimilation; and in this way, what ought to have been excreted by the organs destined for that purpose is allowed to circulate with the blood. Hence the diseases which are consequent on the impure condition of the blood.

In an article on the yellow and remittent fever of the African coast, in the *Edinburgh Medical Journal* for March, 1857, Mr. Baikie remarks, "I have seen remittent fever attack a party of men, when encamped on a dry gravelly river-bed, with hardly a trace of vegetation near, and to be there as severe as it would be in the delta of an African river." Where, more than the bed of a river, whose waters have been but recently dried, could there be found, under the surface, water which would yield an abundant evaporation by the heat of a vertical sun? He states also, that "malaria is, therefore, terrestrial in its seat, and, possibly, vegetable in its origin. Its materialism is further proved by the protection afforded to persons passing the night in swampy districts by wire gauze, or even by a thin mosquito curtain, under the cover of which sleepers may usually repose almost in perfect security, the fine structure seeming to act like the safety lamp of the miner, in preventing the ultimate atoms of the poisonous gas from passing through the minute network, and so reaching the individual."

The reason why a person in a marshy or damp place can sleep with comparative safety under a wire-cloth cover, or mosquito cloth, may be accounted for in the following manner :—Dry air is well known to be a bad conductor of electricity. When a person is laid on the ground with a blanket or some equivalent under him, and without any covering over him, the electricity, radiating, will be carried away with the radiating moist air that is passing around him. If there is any motion of the wind, that portion of air over the sleeping person will be carried off, and a new portion of cold, damp air will take its place, to be always replaced so long as the sleeper lies. This will effectually lessen the electricity in him, and give rise to derangement consequent on a negative electric condition. The wire-cloth, on the contrary, preserves the same air in contact with the person on the ground, and this air will become heated, and its being motionless will tend to prevent radiation from the body, and consequently keep it in a positive electric state. It is known that, by spreading a fishing-net over shrubs during a frosty night, the shrubs will be protected from the effects of the cold. This beneficial effect is produced to the shrubs, in no other way than by keeping the air under the net and around the bushes in a quiescent condition, whereby it is not carried away by its usual undulations; and the radiation from the earth under the bushes warms the air, so that, by this means, the temperature is hindered from being so far depressed as to damage the vegetation of the bushes.

The evil effects of being asleep in a marsh may be produced by the continuation of the evaporation from the marsh, whilst there is the absence of the compensating heat of the solar rays. They may arise also from the diminished activity of the vital operations. The respiration would be slower, the digestion less active, and the assimilation proportionally quiescent, which will cause but a limited evolution of vital electricity, while there is at the same time the abstracting operation of active evaporation. Dr. Baikie mentions that African remittent fever depends on the operation of existing marshes.* "Remittent fever in Africa, as elsewhere, is invariably the result of exposure to malarious influences, and it is most prevalent and most fatal in low, swampy situations, where the poison exists in greatest abundance. In high and dry situations it is comparatively rare, or altogether unknown. Its constitutional effects do not show themselves until after a period of incubation, varying, according to the temperament and powers of resistance of the individual, and the amount of poison imbibed, from five to sixteen or eighteen days; but, from the numerous careful observations by naval medical officers, the average appears to be from nine or ten to twelve or fourteen days—so much so, that if the latter term has elapsed after exposure to pestilential miasmata without any sickness occurring, all danger may, in most instances, be reckoned as over. I was lately enabled to verify this in my own case, as knowing

* Edin. Medical Journal, March, 1857, p. 804.

pretty accurately the time when the poisonous dose was imbibed, I found the period of incubation to be exactly ten days." Dr. Baikie considers that it is no longer doubtful, that intermittent and remittent fevers depend for their origin on some agency connected with the marshes, as he states that where there are no marshes there is no fever, and that in dry situations it is rare and unknown. It is only because those situations are dry, that there is no malaria; for as soon as these dry situations have been saturated with water, and exposed to the solar rays, there is raised up, out of these otherwise healthy regions, a malaria as formidable as that from the most reeking swamp. This has been manifested in many regions of the earth, where there is long-continued dry weather, and where there are afterwards copious rains followed by free evaporation.

Dr. Baikie gives his testimony to the gradually operating influence produced on the body by the agency arising from the presence of the marsh. According to the principles here advocated, the incubation may be produced in the following manner:—The evaporation from the marsh is continually altering the electric condition of the vicinity of the marsh. Whilst the sun shines, during the day, there is a more positive condition than at night, when his rays are withdrawn, as then the negative condition takes place; and those individuals who expose themselves to the operation of influences so much lower in electric tension will soon experience some evil effects. When the electric condition of the earth is at a stage below that of the animal, the earth will draw from him a certain amount of animal electricity, but, at first, not so much as to disable the vital functions. If, however, the abstraction continue day after day, the nervous power becomes so far reduced as to be unable to continue the healthy functions of life, and then follows disease. The interval of time from the first symptom of uneasiness, till the complete suspension of healthy action, will form the whole period of incubation. In yellow fever, and severe cases of remittent, the violence done to the powers of life is so great and speedy as to damage the vital functions at once, and vitiate the blood, engorging and breaking up the capillary vessels, allowing no interval of time to constitute the incubation.

CHAPTER IV.

ON VARIATIONS OF ELECTRIC TENSION AS THE CAUSE OF CHOLERA.

Besides the conducting power of evaporation, to draw off electricity from the earth, and the objects thereon, there may be some occult influence in operation, in the mineral strata which constitute the crust of the earth, of good conducting power, which may disturb the regularity of the distribution, and unsettle the equilibrium, of the electric fluid on the surface, withdrawing it probably into more central regions, leaving the surface in a highly negative condition, compared with that in which it was before being thus acted on. In this way may be produced those epidemic and occasional attacks of pestilential disease, which cannot be attributed even to the existence of those circumstances which are generally looked upon as remote causes. In this way may have arisen pestilential cholera, in the temperate regions of the earth,—a disease which was for a long time considered to be endemic in hot climates, as it primarily raged in those countries which are found in the torrid zone. It was considered that, like the other pestilential diseases peculiar to hot countries, the material for its production could not exist in the colder regions of the globe. But variations of electric tension may be produced by the powerfully operating electric agencies of internal combustion and volcanic action, which must be occasionally going on in various parts of the world, and which must be felt on the surface, altering its relative electric condition. As evidence that there is more than hypothesis in this statement, the author will refer to the observations of M. Andrand, which were made during the prevalence of cholera in Paris, in the year 1849. In a communication made to the French Academy, dated July 10th, 1849, he states, that his electric machine was very powerful, and continues,—"I have remarked that, since the invasion of cholera, I have not been able to produce on any occasion the same effect. Before the invasion of cholera, in ordinary weather, after two or three turns of the wheel, brilliant sparks of fire, of six centimetres in length, were given out. During the months of April and May, the sparks obtained by great trouble have never exceeded two or three centimetres, and their variations accorded very nearly with the variations of cholera. This was already for me a strong presumption that I was on the trace of the important fact that I was endeavouring to find. Nevertheless, I was not yet convinced; because one might attribute the fact to the moisture that was in the air, or to the irregularities of the electric machine. Thus I waited with patience the arrival of fine weather and heat to continue my observations with more certainty. At last fine weather; and to my astonishment, the machine, frequently consulted, far from showing, as it ought to have done, an augmentation of electricity, has given signs less and less sensible; to such a degree, that during the days of the 4th, 5th, and 6th of June, it was impossible to obtain anything but slight cracklings without sparks. On the 7th of June the machine remained quite dumb. This new decrease of the electric fluid has perfectly accorded with the renewed violence of the cholera, as is only too well known. For my own part, I was not more alarmed than astonished; my conviction was complete. At last, on the morning of the 8th, some feeble sparks re-appeared, and from that hour the intensity decreased. Towards evening, a storm announced at Paris that the electricity had re-entered its domain; to my eyes, it was the cholera which disappeared with the cause which produced it. The next day I continued my observations; the machine, at the least touch, rendered with facility some lively sparks." He states, that in the six days following the 8th of June, the mortality in Paris fell gradually from 667 to 355.

A gentleman in Glasgow, during the prevalence of cholera in that city, in the winter of 1849, informed the author that he had an excellent electric machine, which at all times yielded large sparks of electricity with the utmost facility. He was very much in the habit of using it, and was well acquainted with the science. He stated that at the time above specified, when cholera prevailed, he had the utmost difficulty in producing the slightest sparks, notwithstanding the rubbing, and heating, and brisk turning of the cylinder of his machine. As it was no part of this gentleman's object to trace any relation between this low tension of terrestrial electricity and the cause of cholera, he took no notes or dates as to the time when the peculiarity began and when it went off.

om the observations of these two gentlemen, it vident that there was a connexion between the r state of the tension of terrestrial electricity and the existence of cholera. In the one case the evidence was quite unconnected with any idea of theory, and in the other case there were no definite notions entertained by M. Andrand regarding the nature of the connexion between cholera and the diminished tension of electricity. He evidently connects the cause of cholera with the amount of electricity existing in the air, as he remarks that "he felt with joy that the vivifying fluid was returning to the atmosphere."

These facts are certainly very conclusive in support of the theory here advocated. They distinctly indicate that the electric condition of the mineral strata and superincumbent mineral débris on which Paris and Glasgow rest were, at the period when cholera raged, in a negative or low state of electric tension.

In contemplating the phenomena which are presented by the symptoms of cholera, and at the same time admitting the identity of electric and nervous power, the above-mentioned facts have a very satisfactory corroboration, as may appear by making an analysis of the symptoms of this complaint. There is found in cholera a disturbance of the central nervous organ, as displayed in deranged sensorial manifestations. And there is often, in its earliest approach, a sudden and great depression of strength, evidently arising from a large abstraction of nervous power. This is evinced by the nervous agitation, and the loss of muscular strength, and the irregular and convulsive spasms of the muscles.

Then there is the arrest of absorption, assimilation, and secretion. The mouth is dry and the excretion from the kidneys is arrested. In consequence of the enervation of the capillaries of the bowels, the action of the absorbents becomes inverted or may remain passive, allowing the serous part of the blood to escape, the clot being too gross in composition to follow, but filling the capillary system, it produces the livid appearance of the skin. The loss of nervous power is felt in a distressing manner on the respiratory organs, there being difficulty and oppression of the chest during their action. This oppression is produced by the failure of the nerves which supply them. They are lame in their motion, and little more than mechanical in their action, as the vital function, and, consequently, their chemical action, has ceased, the air being thrown out cold as it is taken in. The heart soon ceases to act with any degree of vigour, both on account of the cardiac plexus suffering from the debilitating effects of the general nervous failure, and on account of the want of the usual stimulus of the blood, the fluid part of which has almost all been ejected from the system by the inverted action of the capillaries. Speedy coldness of the body is characteristic of cholera. The low temperature of the patient in this disease is satisfactorily accounted for by the cessation of chemical action, as there is no longer any evolution of caloric—any evolution of that power, the abstraction of which, at the outset of the malady, robbed the system of the power to evolve more, and led to all the subsequent fatal results. The primary exciting cause of cholera seems to be more powerful than that which usually causes even other pestilential diseases. There is not even the reactionary movement of a rigor, which is exhibited at the commencement of most other diseases. The debility is much more speedy, and the prostration is much more complete. That there is a powerful active agency operating to produce cholera is evident from the powerful and sudden effects produced on the body when first attacked by the disease. There is a very sudden depression of strength, even to such an extent that the patient is sometimes struck down at once almost lifeless. On what part of the body could such a malign power be exercised? It must be on a commanding and controlling portion of it. It must be on the nervous system, when the effect is so evidently a failure of its power.

By adopting the principle that the nervous and electric powers are identical, how easily and satisfactorily may the phenomena presented in the following passage from Dr. Copland be accounted for:—"That the vital energy of the nerves distributed to the respiratory, the circulatory, and the secreting organs, is either uncommonly depressed or entirely annihilated, is shown by the nature of the characteristic symptoms constituting the malady. The state of the respiratory function, particularly the laborious inspirations and rapid expirations, the coldness of the expired air, the involuntary and forcible retraction of the epigastrium and hypochondria, and the inexpressible oppression and anxiety referred to the chest,—all indicate that the vital actions of the lungs are nearly suspended, and that the state of collapse and congestion presented by them soon after death had actually commenced during life. The impaired actions of the heart, the small, weak, and nearly abolished pulse, and the black colour of the blood, evince a suspension of those changes produced upon this fluid during respiration, and demonstrate, not only a paralysis of the nervous energy of the lungs, but a marked diminution of the nervous power actuating the heart and arteries; the loss of vital or nervous power being necessarily followed by a suspension of the changes produced upon the blood in the lungs, by congestion of the abdominal viscera, by an exudation of the watery or serous part of the blood from the digestive mucous surface and the discharge of it from the stomach and bowels, and by a total cessation of all circulating and secreting actions, owing to the loss of organic nervous power and to the change in the state of the blood. The vital or ganglionic class of nerves (which forms a sphere of intimate union with each of its parts, supplies the lungs, the heart, and blood-vessels, and all the digestive, assimilating, and secreting viscera, and, when powerfully impressed in one part, experiences a co-ordinate effect throughout the whole) is primarily and chiefly affected. Hence the alteration of all the natural secretions so rapidly supervening upon the morbid impression made by the efficient cause of the disease on the nerves of the lungs; hence the almost total abolition of circulation, assimilation, and secretion; hence the congestion of the large vessels and vital organs; and hence, also, the rapid extinction of voluntary power, as a necessary consequence of the suspension of those changes which, being produced in the blood, support the nervous energy, and all the voluntary and vital actions. The retchings, evacuations, and spasms, so generally observed, frequently follow upon any sudden diminution of vital power, and upon congestions of the nervous centres,—and seem to answer wise purposes in the economy, inasmuch as they tend, by their influence on the circulation, to bring about a natural restoration of the vital actions, and to throw off the injurious load by which the springs of life are oppressed." Every lesion here enumerated is attributed to failure of the nervous power. The respiratory, the circulatory, the secreting organs are all depressed. The nervous energy of the lungs, the ganglionic nerves, those which give power to the assimilating organs, are all affected with the same depressing influence. In this way can be explained, in an intelligible manner, the changes which take place in the progress of cholera. The sudden depression of strength, the marked failure of all the vital powers, the vitiation of the fluids of the body, the consequent ejection of the contents of the blood-vessels, which are no longer fitted for the purposes of vital elaboration, may be all intelligibly traced to depend on a depression of the nervous power, which depression is produced by an abstraction of nervous power by a highly negative condition of the earth, or other body, or electro-negative agency, brought into contact with the person acted on.

In the section immediately following the above, the doctor mentions the changes which take place in the blood in this disease.* "Whatever may be the exact nature of the exciting cause, and whatever may be its mode of operation on the frame,—whether this cause primarily affects the organic nervous system and the blood, consecutively, through the agency of

* Vol. iii. p. 123.

this system, as now maintained, or whether it passes at once into the circulation from the air-cells of the lungs, and affects the organic nervous system secondarily,—there cannot, at least, be any doubt of the very remarkable changes produced on the blood in the course of the distemper. The analysis of the blood, of the bile, and of the evacuations, by M. Le Canu, Dr. O'Shaughnessy, and others, show that, at an advanced period, the blood has lost one-half of its serum, a considerable portion of its fibrine, and most of its carbonate of soda; whilst the rice-water-like evacuations consist chiefly of the serum of the blood, containing albumen and carbonate of soda, and other saline ingredients which are deficient in the blood. When the disease has gone on to the febrile or reactive stage, then urea accumulates in the blood, and even in the bile, owing to the paralysed state of the kidneys. It is not improbable that a considerable change is going on, in a latent manner, in the blood before the serous portion of it is discharged from the digestive mucous surface; and that this change takes place chiefly in the lungs, and affects the vital relations subsisting between the serum, fibrine, and coloured globules, as well as between the capillary vessels and blood circulating through them; and that the fully developed period of the malady is the result, first, of this change, and, second, of the evacuation of the serum and other ingredients of the blood; capillary circulation in vital organs thereby becoming arrested. This state of the blood, in connexion with the impaired function of the lungs, of the kidneys, and of the liver, is evidently the source of the consecutive fever."

The prostration of strength is an early symptom of this disease, and what more likely to produce the prostration than an abstraction of nervous power? How much more intelligible is the idea that abstraction of power has produced the debility, than that an unknown ideal poison has entered the blood, and produced the impurity? How much more probable that the nervous power has been withheld from the kidneys, and that they have been thus rendered unfit to elaborate the urea from the blood, and hence its presence there? the other organs have been debilitated from the same cause, and thus has been produced the general vitiation of this fluid.

Such a powerful cause, if depending on altered electric tension, must operate less or more on all individuals who are within the circle of its operation. The effects of electric variations on the living animal will be most evident in those regions where this element is most abundantly present. In the torrid zone this is found to be the case. Countries in this portion of the globe are more frequently visited with cholera than are those of a higher latitude and more moderate temperature. But, even in high latitudes, the operation of a general cause is made evident, where sufficient attention is directed to it. Dr. Copland, speaking of his experience of cholera in London,* says, "Although but comparatively few were carried off by the pestilence, yet very many experienced severe indigestion, flatulence, and diarrhœa, with marked vital depression, sometimes with slight spasms, these ailments being either removed by restorative and astringent medicines,

* Vol. iii. p. 103.

or successfully resisted by the powers of the constitution. And I may add, that there were very few medical men who did not experience these symptoms in their own persons—at least the dyspeptic symptoms, if not the diarrhœa—during the period of their attendance on cases of the distemper." From these remarks of Dr. Copland, it would appear that, whilst cholera raged in the places pointed at, there was a general indisposition, a general tendency to irritation in the digestive and assimilative organs, amongst the inhabitants generally, and the number thus affected would be much greater than came under the cognizance of medical authority. This is just what might, *a priori*, be suspected on the principles here advocated. There is always, in every community, a great number of different constitutions, and of individuals of different susceptibilities, modified both by moral and physical causes. In a locality where the electric tension of the earth is very low, that is, very much negative, there will be a different effect experienced by individuals, according to the different susceptibility of each, and in proportion to the power of the depreciatory influence operating on them.

These effects upon the community generally, during the prevalence of pestilential disease, have been found to exist in some cases for a considerable time before the outbreak of the disease. Mr. Parkin remarks, that "from the facts which have been collected by numerous writers, we are bound to infer, that the epidemic influence, whatever that may be, is in operation for some time (in fact, many weeks, if not months) before it produces any severe effects. This phenomenon was particularly observed during the prevalence of the epidemic cholera; for not only was the severe form of the malady preceded for many days by slight attacks of diarrhœa, but a variety of anomalous symptoms indicative of derangement in the digestive organs was observed to prevail for many weeks before the epidemic manifested itself in its most severe form." This may depend on the locality, where the people are thus affected, being in a less negative condition than is required to produce the full development of the disease. The nervous power may be so far reduced as to act languidly on the viscera employed in the vital processes, and produce the discomforts that arise from indigestion, and other derangement of the primæ viæ.

The outward circumstances of an individual influence, in great measure, his susceptibility to attacks of disease. The contrariety of these in the members of a community is very great. They may be classified in the following manner:—there are the well-fed and the ill-fed, the well-clothed and the ill-clothed, the well-housed and the ill-housed, the strong and the weak, the sober and the dissipated, the timid and the brave. The well-fed have little susceptibility, because of the large quantity of electricity which is evolved during active and healthy digestion, and can bear, with comparative impunity, the abstracting power of a negative condition of the earth. The ill-fed, on the contrary, having a smaller evolution of electricity, in consequence of the smaller amount of ingesta subjected to the digestive powers, and having less to spare, will more readily become victims to pestilential disease. Dr. Copland states, that "the mortality, as well as the susceptibility to attack, was certainly greatest among the poor and ill-fed."* Mr. Scott states, that in India the poorest of the people, who suffered great privations, were its principal victims. Then, there are the well-clad and the ill-clad. Supposing that the individuals in both these classes are fed alike, and that the evolution of electricity is equal in both, the electric fluid of the ill-clad will escape more readily than that of the other, and if the abstracting power be strong, it may draw off more than can be spared; whereas the person that is well-clad is surrounded by non-conducting media, which prevent the caloric from being given off.

The well-housed have the advantage over the ill-housed, in being in a great measure insulated. They have their wooden and carpeted floors, their non-conducting hair and feather beds. The ill-housed have their floors often of the bare earth; and this is very often in a damp muddy condition. The floors are also sometimes of stone, and are then always good abstractors of the vital element. In their beds, also, they are not so well protected, as they have neither the hair nor the feathers; and the covering may be insufficient. Then, there are the strong and the healthy, with all the vital processes going on vigorously, and able to spare with impunity a large amount of electricity. The weak, from causes either hereditary or acquired, are ill prepared for the abstracting operation of close contact with the earth, when in a state of negative electricity; because the defect, either in the respiratory or assimilating organs, will hinder a sufficient evolution of electric fluid; and in this state disease

* Dictionary of Practical Medicine, vol. iii. p. 101.

may be readily induced. Dr. Copland states that "the prevalence and rate of mortality, as far as my own observation enabled me to judge, were remarkably increased by previous ill-health, by debility, and by advanced age."* Then, there are those that suffer from disease of the respiratory or digestive organs or other important viscera. The vital processes of digestion and respiration, in a state of disease, are ill qualified to produce nervous power, and enervation will seriously impede the integrity of the vital operations, which will be still further seriously injured by being subjected to any abstracting influences. Then we have the sober and the dissipated. The former, with a good constitution, has nothing to fear. The dissipated, on the other hand, has all against him; his digestion is imperfect, his internal organs are all over-wrought, have little power to keep up an adequate supply of the vital element, and readily succumb to the malign influence of the earth in a negative electric condition. "To *intemperance*, more than to any other *single* cause (says Dr. Watson), may the proclivity to become affected by this (epidemic) species of cholera be ascribed; and especially to the intemperate and habitual use of distilled spirits. This fact was peculiarly manifested in the selection, by the disease, of its victims in this country; and it has been remarked almost everywhere else."† The spirituous potations, in which the dissipated indulge, are, in their composition, so destitute of nourishing properties, that they cannot be assimilated, they cannot strengthen the body, while the powers of the system are exhausted, by throwing out from it those

* Vol. iii. p. 101.

† Practice of Physic, vol. ii. p. 467.

mischievous fluids which cannot be taken up, and therefore cannot nourish the body. The digestive powers, also, are so worn out by this unnatural draft on their energies, as to be unable to operate with sufficient power on the ingesta, to keep up a supply of nervous electric power, to secure the integrity of the assimilating process. Then, there are the timid and the brave. The former may be in the same circumstances as the latter, and have the same susceptibilities; but the latter, being fearless of ill consequences, eats well and sleeps well, while all his functions go on vigorously, producing a large supply of electric power, and can, with success, resist the effects of abstracting influences. The timid, on the contrary, eats little, sleeps little, and his mind is tortured with apprehension. This depressed condition of the mind causes a corresponding depressed state of the body. The result is, that there is comparatively little evolution of caloric, so that the abstracting influence of the earth places a person thus circumstanced in jeopardy from lessened electric tension.

Exhaustion from over-exertion is another condition which can ill bear the abstracting power of a negative electric state of the earth. The nervous energy required to keep up a lengthened continuation of muscular action must of necessity be large, and will absorb nearly all the electricity which may be evolved during digestion and respiration, and leave scarcely as much as serve to support the vital operations. When to this exhaustion is added the still further exhausting effect of a negative electric soil, there will be produced a ready predisposition to be affected with any prevailing malady. It is very often observed, when an epidemic condition of a locality exists, that the first person seized is a pauper, just arrived from a long journey. This pauper, in all probability, would be neither sufficiently fed nor clad; there would be neither the full elimination of electricity within, nor proper means taken without, to prevent the radiation of the vital element; and, when in this condition he is exposed to an abstracting locality, he will readily suffer from the morbid influences of a deficiency of electric fluid. There may be produced enervation of the visceral capillaries, and the derangements depending thereon.

It is well known, that when our Indian armies are on the march, and when they encamp on the bank of a river, they very generally become affected with cholera. There are here two unfavourable elements in the case of the army: there are the fatigues of the march, and the fluctuating nature of the electric tension, so often found in consequence of evaporation on the banks of rivers. Dr. M'Kay states, that those men of the crews of the men of war belonging to the Black Sea Fleet at the Crimea who had the most severe and fatiguing duty to perform, were those who suffered most severely, and whose cases generally terminated fatally, from cholera.

In reports of the history and progress of cholera, the information respecting the topographical and meteorological phenomena of those places where this disease is known to be endemic and frequent in its appearance, is very fragmentary and incomplete, as the attention of those who have good opportunities has never been directed to the subject with an intelligent and satisfactory aim; their minds being bereft of the necessary curiosity by the foregone conclusion, that the cause of this disease is nothing more than an unknown and inappreciable miasm, or a poison generated in the diseased, and operating prejudically on the sound.

In a report of the American Medical Association for 1855, it is mentioned that cholera made its first appearance, and was most virulent, on the banks of rivers. The immigrants at New Orleans were the first attacked, and the most frequent victims. This class of people, of all others, will be most readily affected with pestilential disease. They are almost always subjected to great privations; their food is sometimes unwholesome in quality, and sometimes stinted in quantity; and their accommodation on landing may be in a hovel or the damp ground, and their bed correspondingly uncomfortable. This condition of the poor immigrant will make him highly predisposed to disease. New Orleans is damp and swampy all round, and notorious for its insalubrity. It is a hot-bed for yellow fever and other diseases. The report states that "cholera was traced in the surrounding districts, along the great rivers and most frequent routes. In the State of Missouri, cholera, during the several years, was, in a great measure, confined to the towns on the river banks." These American rivers drain an enormous extent of territory, and are consequently subjected to great inundations, which overflow their banks, and, after the receding of the waters, the soil remains saturated with moisture, which, when exposed to the rays of a nearly vertical sun, will cause ready evaporation, and consequent low electric tension.

In an abstract of a report on epidemic cholera, by Mr. William Scott, in the *Edinburgh Medical Journal* for 1825, a great many places are mentioned at which cholera appeared, but it is not stated whether they are situated in dry or damp situations. It is mentioned that cholera had prevailed at Gangam, a town by the sea-coast, and also at many other towns; but it is not said whether, while these towns were by the sea-coast, they were also situated on the banks of rivers. Rivers in that climate, at their embouchement into the sea, very frequently resemble the appearance of a swamp. The following, however, is given:*—"At Masulipatam on the coast, the first cases appeared on the 10th of July, among the convicts confined in the fort, in a low, damp, ill-ventilated, and very crowded apartment; and about the 20th, it was observed in the town and neighbourhood, where it was very general during August, declined rapidly in September, and disappeared early in October, while the weather was chill and the rain the heaviest." The subsidence of cholera at the commencement of the heavy rains may, at first sight, appear unfavourable to the principles here advocated. But the coldness of the temperature, and the very abundance of the rain, satisfactorily account for it all. The low temperature would not favour the steady evaporation, and consequent lessening of the electric tension, as the large quantity of the water would so cover the ground as to cause the same condition as is found in a large body of water, as in a lake, where there is little evaporation,

* Edinb. Med. and Surg. Journ. for July, 1835, p. 182.

in consequence of the heat-absorbing power of a large volume of water. In the case of the convicts, there is no difficulty, as the dampness of their prison was sufficient to keep up a constant drain of vital electricity from their bodies, and produce the enervation of the capillaries of the abdominal viscera, which may be the proximate cause of Asiatic cholera. There is also the depression of mind which is consequent on incarceration. The digestion becomes languid, and, besides its languor, the stomach may require to operate on indigestible diet, and the other assimilating organs may fail to provide their ordinary amount of the vital fluid, and thus deprive the nervous system of the supply of electric fluid which is contributed by this operation. Mr. Scott continues to give an account of the progress of cholera along the eastern or Coromandel coast of the peninsula, during the years 1818 and 1819, from Gangam and Aska in the north, to Palamcottah and Tinnevelly, not far from Cape Comorin, at the southern extremity of the peninsula. Cholera manifested itself in the district of Palnaud, in a town called Guntoor. It is mentioned that, at the "beginning of the westerly rains, and continuing until the termination of the rainy season, it is reported to have been most fatal duing the prevalence of bleak westerly winds, and in villages situate in the vicinity of tanks. The *Banians*, or merchants of the town of *Guntoor*, a little to the south of the Kistnah, whose dwellings occupy a wide dry street, almost entirely escaped the disease, while the *Brahmins*, who inhabit a close, damp alley, suffered in as great a proportion as any other class of people." In this extract it is reported that cholera took place and continued during the rainy season, and in villages in the vicinity of tanks, and during bleak and westerly winds. The rain would not be so copious as completely to cover the grounds, and form a lake; but would be in such quantity, as to be raised almost as soon as it had fallen, and the bleak westerly winds would assist it in withdrawing the electricity from the animal body. The Banians, who occupied the wide, dry street, had almost an immunity from the disease, as the dry condition of the vicinity had an insulating effect, whilst the Brahmins, inhabiting a low, damp alley, suffered as much as any portion of the people. The continual operation of the dampness of the abodes of these Brahmins produced a constant draft of electricity from them, whilst the additional effect of the evaporation of the rain would cause a still further loss of the vital element.

Cholera is represented as having extended over the whole Zillah of Nellore, ravaging the villages, and traversing "the whole Zillah, except its two south-west divisions, which entirely escaped the visitation. These parts, which are the most elevated of the Zillah, are populous and much frequented by merchants."* It was during the rainy season that the pestilence prevailed. At Nagore it began "principally among those natives whose occupations exposed them to the weather, which was damp and rainy." If contagion could propagate cholera, where could it spread more readily than in a district traversed by people engaged in trade and commerce?

Of the more northern regions of the earth, physicians have remarked that the state of the weather

* Page 184.

and the facilities for evaporation have something to do with the prevalence of cholera. Mr. Parkins observes, "The greater number of physicians, says an author,* speaking of the slighter affections which ushered in the epidemic cholera in Berlin, attributed these accidents to the influence of the summer, which was hot and wet, with a remarkable absence of all storms. A singular and almost unknown circumstance, continues the same writer, also contributed to augment the humidity of the atmosphere: this was the inundations of the banks of the Spree—a phenomenon which was several times repeated without its being possible to explain properly the cause. These spontaneous inundations were observed at the same time in Russia, in Poland, and a great part of Prussia. In England, also, the same remarkable vicissitudes have been experienced from the above period (1831) to the present day; and what is worthy of note, the same order has been observed in their progression as in the instances before referred to; for the epidemic was preceded and ushered in by sultry close weather and an unusually hot and dry summer; while it has been followed by great and unexampled cold and unusually wet and rainy seasons, with floods and inundations in particular parts of the country.

"In addition to the above, there are certain other phenomena, which have been recorded by different writers, and which deserve consideration at the present moment. One is the appearance of a fixed cloud, and the other the occurrence of luminous arches, or the Aurora Borealis. The appearance of a fixed cloud—a phenomenon, says Mr. Jameson,

* On Epidemic Diseases, p. 102.

which has frequently been observed to attend all epidemics or plagues, was also remarked in Calcutta. *To the experienced eye it clearly foreboded*, whenever observed, *the return of cholera.*" There has always been a suspicion in the minds of observant medical men, that moisture had something to do with epidemic cholera. Amongst those who believe in the instrumentality of miasm, there is an admission that the poison is inoperative in the absence of moisture. The contagionists, also, believe that moisture is necessary to convey the morbid emanations from one body to another. The physicians of Berlin admitted the connexion between the presence of moisture and the prevalence of cholera. The heat and moisture were supposed to cause the slighter affections which ushered in the epidemic cholera. It has very generally been observed, in those places which have suffered from this pestilence, that ill health very uniformly prevailed before the inroad of the malady, and during its prevalence. This general illness and the cholera must arise from one and the same cause, as that which operates so fatally on a given number of people must operate detrimentally on all, causing in some the slighter affections, and in others, according to their various dispositions, more grave and dangerous complaints.

It is further stated, in the abstract of Mr. Scott's report,* that "The first spot in the northern and central region of the peninsula at which it is represented to have appeared is Nagpoor and the neighbouring villages, where it was observed about the middle of May, 1818, when it was general and fatal among the inhabitants; but no case appeared among

* Ed. Med. and Surg. Journ. for July, 1825, p. 185.

the troops until the 26th or 27th of May, when three or four men of the depôt corps were attacked and died. On the 30th of May, a large detachment of Bengal and Madras troops arrived at Nagpoor from the siege of Chandah, took possession of certain huts near the Sittahildee hills, which they had formerly occupied. Though previously in good health, they had scarcely taken possession of their quarters when it appeared in a violent manner among the Bengal troops and their followers." There is here no mention made of the state of the weather, whether it differed at the former time, at which the troops occupied the huts, from what it was at the latter time, when there was so much mortality. The men themselves, however, were in different circumstances. At the first time that they occupied the huts, they were, in all probability, at ease, enjoying plenty of good nourishment. But when they returned from the siege of the stronghold, they would be in very different circumstances. Their having borne the fatigues of a march, besides the labour and anxiety of a siege, would make a large draft on their nervous energies; and, moreover, one usual source of supply may have been curtailed, the food they had obtained may have been insufficient in quantity, and different in quality, from that to which they had been accustomed,—an evil commonly attending besieging armies. They had also been subjected to the privations of a camp life, such as exposure to all kinds of weather, and also sleeping on the ground, with but a very imperfect non-conducting body under them, which would give facility for the escape of nervous power, and this, too, during sleep, when the vital operations are least active, least able to provide a supply of nervous energy. Hence might arise the enervation of the abdominal capillaries peculiar to cholera, or the contamination of the circulating fluid peculiar to some other disease.

Mr. Scott states afterwards that cholera seized a regiment while encamped in the vicinity of the Madoor river, and that it was destructive in villages adjacent to the Cavery river, especially Errode, and Carroor, as also in towns on the Godanery and Pennar rivers. At Salem and Sankerrydroog, the disease appeared about the end of August, after a long continuance of rainy weather. The inhabitants of the hills, in the neighbourhood of Salem, prohibited all communication with those of the valley, and it is said that they were exempt from any attack.* "At Tellicherry, few cases occurred till the 25th of November, when it became frequent among the poorer and most indigent inhabitants, fishermen of the lowest order, and causing much mortality among the aged, infirm, and dissolute. It is remarkable that neither soldier, policeman, nor prisoner was attacked."

There are many other towns mentioned in the abstract of the report, but as nothing is said about their topography, or proximity to lakes or rivers, they cannot be made available in our inquiry.

M. L— Ch. Roche, in an article in the *Dictionnaire de Médicine et de Chirurgie Pratique* states that—"The Cholera Morbus is endemic in India. According to the general opinion of physicians who have observed cholera in this country, it takes its rise under the influence of strong heat, joined to great humidity,

* Page 191.

and especially when they immediately succeed to a cold and humid atmosphere. It was thus that it took place during the virulent epidemics of 1817 and 1825. Also, it is almost always in these circumstances that it is observed to develop itself in Europe. It is much more frequent also in the southern countries of this part of the globe, in Spain, in Italy, and in the south of France, for example, than in the north . . . . . . In India, such is especially the influence of *régime* on the production of the disease, that the Europeans, better lodged and better nourished than the natives, generally preserve their health in the very focus of the most virulent epidemic; whilst those who assimilate themselves most closely to Indian habits of living, are more frequently attacked with cholera. In fine, it is the most feeble and the most miserable of the Indians, the Parias, for example, who perish in the greatest numbers. It has been remarked, besides, that the disease rages with most fury upon the banks of rivers, and after great inundations, and in marshy places; but, as it very frequently develops itself also in the opposite conditions, nothing can be concluded from this fact; which deserves, however, to be better observed than has been done hitherto. Nothing can be concluded from this fact, I say, but that the presence of marshes adds to the seriousness of the evil." These opposite conditions may, in most cases, be more apparent than real. In how many situations is the surface dry like a desert, yet, at a short distance under it, in the subsoil, there is complete saturation of the ground, yielding to great heat an abundant evaporation. It is not known that cholera has ever broken out in the burning deserts of hot countries. The comparative immunity of the Europeans in the very focus of this destruction, compared to that of the feeble and miserable Parias, is justly attributed to the good feeding and good housing of the former; and this is still more clearly brought out in the statement, that those Europeans who assimilate themselves most closely to Indian habits of living, are more frequently attacked with cholera. Now the reason why it is that the good feeding and the good housing of the Europeans protect them from an invasion of the disease, is that the good feeding causes a plentiful elimination of electricity, from the healthy action of the vital operations; and the good housing defends them from the abstracting influences which, especially at night, draw off the inbred electro-nervous power. The poor Parias, in consequence of their insufficient feeding, and the languor of the vital operations, have a comparatively small supply of electricity evolved during digestion; whilst their imperfect and insufficient housing, perhaps with the bare earth for their floors, and their bodies in contact with it, causes them to be subjected to the powerful electro-negative influences which are produced by the continued evaporation outside their dwellings. Thus these poor people suffer an abstraction of that electricity which their insufficient feeding, and consequent small supply, renders them unfit to bear.

The villages, in warm climates, must, of necessity, be within easy access of water, and, on this account, they are principally found in valleys in the vicinity of rivers. In tropical countries, the rains are copious, so that the rivers are made to overflow and inundate the lands on their banks. When the water returns into its channel, there are generally left large pools, which are ultimately dried up, leaving the ground saturated with moisture. When this is acted on by the rays of a vertical sun, there will be caused a speedy evaporation, which will disturb the electrical relations of the region, changing it from an electro-positive state into one highly negative. It is stated that, at Tellicherry, the indigent, the aged, the infirm, and the dissolute were the principal victims to cholera. This was, probably, the experience in all other places where cholera was particularly virulent; and its being more apparent in one place might depend on the electric condition of the locality, a less negative condition being required to produce the disease among the infirm and dissolute than among the sober, the vigorous, and the healthy. This latter class of people, being better supplied with electro-nervous power, would bear with impunity an abstraction which would detrimentally affect the other. It is the experience of all medical men, in all places and in all countries, that destitution and dissipation cause a great predisposition to cholera. The reason is, that they produce a condition of the system ill able to bear up against such a disease as this.

It has been already observed that occult influences may be in operation in the mineral strata constituting the crust of the earth, and which are of good conducting power, which may disturb the regularity of the distribution and unsettle the equilibrium of the electric fluid on the surface of the earth. The instrumentality most likely to accomplish this is volcanic action, which must have a very powerful influence on the surface of the earth. It is quite unknown what progression is made in the centre of the earth by the vast internal burnings, whose ramifications may spread in directions and to an extent totally inappreciable by the observer on the surface. But if these internal conflagrations really affect the amount of electricity at the surface of the earth—if there be a connexion between these internal fires and the electric tension of the surface trodden by the animal portion of creation—there may yet be a method discovered of finding out, by the alterations thus made, what, to some extent, may be the nature of the variations made by volcanic action. Volcanic action may be operating and causing important changes in the electric tension of the earth, although there be no manifestations on the surface. Thus, there may be active combustion in many situations under the stratified portion of the earth where least expected, which may affect the electrical relations on the surface. There is evidence that volcanic action produces its effects at great distances at the same time. "Thus," says Mr. Parkin, "in the earthquake at Chili, the shock was felt *simultaneously* throughout a space of *one thousand two hundred miles* from north to south. . . . . Again, on the 17th February, 1827, a violent earthquake was felt at Santa Fé de Bagota, in Columbia; and, *on the same day*, at a town in Siberia."* The crust of the earth may be so strong in some situations where there may have been long-continued combustion, that the mass above it cannot be upheaved, although the combustion can force out the lava from the mountain tops. By these burning and smelting operations in the centre of the earth, excavations must be created;

* On Epidemic Diseases, p. 43.

and it may happen that the thinnest portion of the excavation may present itself under the bottom of the ocean, and, at length, the volcanic force, bursting through its confining walls, may throw its smoke among the water, forcing a column of the water above the surface, and thus give rise to that phenomenon known as a water-spout. So long as the burning continued, that portion of the surface above this internal burning would be in an electro-positive condition; but when the water rushed through the opening and filled the excavation, extinguishing the combustion, the cooling would be so effectual, as to convert the neighbourhood of this excavation into an electro-negative state.

It is a well-known fact that all volcanoes are found near the sea or great inland collections of water.

It is stated that "the concussion of the earthquake of Lisbon was severely felt by ships at sea, hundreds of miles westward of the spot where it first commenced." In place of the concussion, as here stated, it is more probable that an opening may have been produced by the earthquake at the bottom of the sea, just under the ships; and the rushing in of the waters into a large excavation may have produced a vibration in the water felt by the ships, in place of a concussion.

The following is from a newspaper paragraph:—"September 17th, at 8·45 P.M.; lat. 27° 28′; long. 78° 28′; with sea perfectly smooth; felt severe shocks of an earthquake. They commenced with a noise like distant thunder, and kept increasing till they sounded like a heavy cannonade some four miles away. About the fourth or fifth shock, it was so heavy that it shook the ship all over, as if she had been struck on the bottom, causing all the window panes and glass to rattle and shake; and it seemed as if some one was rolling a heavy cask about the deck. The shocks lasted twelve or fifteen minutes, but there was but one heavy one. The day had been very sultry, and the sun had a very strange appearance at sunset. The earthquake, or rather the sound of it, was in a N.E. direction from the ship. There was no swell after the shocks, but, on the contrary, the sea remained perfectly smooth.—(Captain Gadd, of the ship 'Pacific,' at New York, from New Orleans)." There is not, in this note, any account of an indication on the surface that, during the effect produced on the sea and the ship, any of the water of the sea was escaping from the bottom; but it would be scarcely reasonable to expect that, out of such a mass of water, all that could escape into a volcanic cavity would make any appearance on the surface; and the opening may have been at a distance from the ship.

No attempt, so far as is known to the author, has been made to estimate the extent of the changes to which the electric fluid is subject on the surface of the earth. This might be accomplished by measuring the difference of tension between one time and another, and finding out what condition is most positive, and what most negative, and forming a graduated scale from the greatest known tension to the least. And, if it be found that the fluctuations of the health of the people coincide with the fluctuations in the electric tension of the earth, it will go far to test the truth of the present theory.

Mr. Parkin, in his treatise, entitled "*On the remote Cause of Epidemic Disease*," endeavours to trace a connexion between volcanic action and epidemic diseases. He supposes that they may depend on some gaseous emissions from the earth, the result of this action below. He considers that the meteorological phenomena may be traced to the same cause,—that hurricanes, typhoons, hail, snow, all arise from the same source. He reasons thus: since volcanic action can produce such phenomena in the regions of the atmosphere, and cause the earth to quake, and tremble, may it not cause those diseases which so frequently devastate the human family? He points out that in the early visitations of pestilence, violent rains, with floods and inundations, manifested the fury of the elements about the times at which those diseases prevailed. In 1338, pestilence visited China in the midst of rains, and floods, and great disturbance of the elements. The accounts from those remote periods must be very imperfect, and cannot be circumstantial enough to show whether the rains preceded the pestilence, or whether they followed, or were concomitant. This author states, that with the commencement of cholera in India about 1817, earthquakes, though uncommon there before this date, had now become very frequent, and recurring at short intervals. Earthquakes are known to be the result of volcanic action, and he mentions that the lofty minarets of Achmedabad, which were thrown down, had stood more than four centuries—an evidence, that no such convulsion had taken place there within that period of time. During the numerous ages which have elapsed between an early recorded inroad of pestilential disease,—when 5,000,000 persons perished in China in one year,—and that which in modern times has laid waste the population of many regions of the world, there seem to have been many of those upheavings and rendings asunder of the surface of the earth which constitute an earthquake. There may have been in the substratified portion of the earth a smouldering combustion, continuing for centuries, which would contribute all this while to render the surface warm, and keep it in an electro-positive condition, and so long as this combustion may have been left undisturbed, this favourable condition of the surface would be maintained. This may be easily admitted, when it is known that volcanic foci retain their heat for ages. Lyell states that lava deposited on the surface, of moderate thickness, requires many ages to cool in the open air; from which Mr. Parkin remarks, "We must conclude that the great reservoirs of melted matter, at vast depths, in the nether regions, preserve their high temperature and fluidity for thousands of years." If it is reasonable to suppose that melted matter exists at vast depths, it is modest to suppose that the heat from melted matter, at a less depth than vast, may, in some localities, sensibly affect the surface, by changing its temperature, and altering the electric tension. The relation, however, between terrestrial heat in general and volcanic action has not escaped the observation of Webster; for he remarks: "An evidence of the effects of fire or electricity on the earth and air, before its explosion, is the *extreme drought* which is so often experienced over whole continents, or the whole world, for six or even twelve months *antecedent to a great eruption of volcanoes*. Many instances," adds the writer, "have been related: it is sufficient here to mention the *excessive* *drought* in 1762 and 1782, *preceding eruptions* of Ætna and Heckla. In these years almost all springs were exhausted, *not only on the continent of Europe*, but also over *a great portion of America*."* Mr. Webster does not recognise the solar heat in his estimate of the cause of the excessive drought which took place in the years mentioned. Although volcanic influences have a very great power in heating the earth's surface, yet the solar beams have a much greater power, when allowed to shine without the intervention of clouds. But when, by any means, the internal combustion is extinguished, though but in part, there will be a cooling effect produced, which will reduce the positive condition of the surface, and produce an opposite or negative condition. That water, finding its way into the excavations which are produced by volcanic action, would have the effect of cooling the cavity, is beyond a doubt; and that water does enter into such cavities is made evident by the emission of steam and vapour from the mountain outlets for volcanic productions. Another ground for the conclusion that water enters these cavities is, that it has been known that a large lake of water has been immediately produced on the occurrence of an earthquake. The lake might be formed by the falling in of that portion of the crust of the earth which is over an excavation filled with water; the water being pressed up by the filling of the cavity with the broken rocks, which are precipitated into the subterranean reservoir by the breaking-up effect of the earthquake.

That large subterranean collections of water exist is further made manifest by the flow, as Mr. Parkin

* Page 75.

mentions, "of an immense body of water from the mouth of the crater, which spreads itself over the plains, sweeping before it the inhabitants, their cattle, and their houses. The effect of these overflowings is frequently more destructive and more to be dreaded by man than the discharge of melted matter, however fatal and injurious such eruptions have sometimes been." Mr. Parkin mentions also that "At Whiterock, in Glamorganshire, the water rose suddenly in the river, floated two large vessels, the least of them above 200 tons; broke their moorings, and nearly upset them. This effect, says the writer of the account, *was not felt in any other part of the river*, so that it (the water) seemed to have gushed out at that very place. This sudden movement in the river, in ponds, and canals, could, we may conclude, only arise from the discharge of water and other matters from the springs which rise up at the bottom of these inland collections of water."

Noah Webster states, that "it has been ascertained beyond all question, that the periods of extensive pestilence and mortality are remarkable for earthquakes and eruptions of volcanoes." "Earthquakes occur during the prevalence of pestilential or other mortal epidemics, but generally in the midst of the period, or sometimes at the conclusion."

That volcanic action can have any other influence in producing epidemic disease than by merely increasing or lessening the temperature of the surface of the earth, and thereby altering its electric tension, is opposed to sound judgment and philosophy, and substitutes a hypothesis as destitute of foundation, and as gratuitous, as the invisible and inappreciable miasm, which has enshrouded the minds of the Profession for so many generations. There are satisfactory grounds for placing confidence in the position here assumed, viz., that alteration of electric tension on the surface of the earth may be produced by volcanic action; but that this action can so operate on the living creation on the surface of the earth, as to produce disease by the emissions from volcanic openings, is purely hypothetical. But volcanic convulsions and meteorological influences may form a combination which may produce great alterations in electric tension. Supposing that a cooling operation were produced on the surface by the sudden extinction of a volcanic fire, and that added to this there were copious precipitations from the clouds, there would be a powerful combination produced for reducing the electric tension of that portion of the earth thus acted on. There is no record of the prevalence of severe pestilential disease, nor are there any accounts of the occurrence of great earthquakes in India, before the appearance of the cholera in 1817, when minarets, which had stood for centuries before that date, were completely overturned. The earthquakes, which immediately preceded the cholera in India in 1817, had, in all probability, cooled the surface from below, and this, associated with the cooling effect of the disturbed elements above, had produced a very low condition of the electric tension. That the elements were disturbed previous to, and coincident with, cholera, as it appeared in India, will appear from the account given by Mr. Parkin, who attempts to trace a connexion between cholera and the earthquakes.

"These atmospherical vicissitudes commenced in India in 1816, a year marked by the absence of the accustomed rains, and the prevalence of great heat and consequent drought; so that the spring crop of grain was entirely destroyed. In the western parts of the province of Bengal the drought was so uncommon as to dry up the rivers. "In the upper provinces," says Mr. Jameson, "the extraordinary scantiness of the rains was yet more remarkable. From Benares upwards, Oude, the districts within the Doab, and those west of the Jumna, were dried up by the long-continued and unceasing heat. In September this unwonted drought gave way, and was succeeded by heavy and incessant rains for many days, so that the whole face of the country was laid under water. The ensuing cold season, also, both in the lower and upper provinces, was raw, damp, and unpleasant, and throughout cloudy, with frequent falls of rain. February, says the writer just referred to, had more the appearance of an autumnal than of a cold-weather month.

"The next year (being that in which the epidemic commenced) was characterized by a very close sultry summer and autumn, and an excessively rainy season. The weather should now, according to the common course of things," adds the writer of the report, "have become cool, settled, and fair; but the continuance of unwonted humidity and warmth in the air, and the frequent occurrence of rain throughout the month (November), proved that the remainder of the year was to proceed with the same strange unseasonableness and insalubrity as that which marked the early part of its course.

"The following year (1818) was remarkable for the like irregularities in the seasons. The hot weather set in about the 20th of February, being earlier than usual; instead of continuing, however, until the beginning of June, as is commonly the case, heavy rains were experienced about the end of February. This sudden change," says Mr. Jameson, "is worthy of particular notice, because *it was at this very time* that the epidemic, after dying away in November and December, and being nearly exhausted during January, took head; and amongst the natives, raged with indiscriminate violence until the end of the following July.

"From this time, said one writer, while speaking of the remarkable vicissitudes that had been experienced in the preceding years, the seasons, after so long a period of extraordinary deviation, seemed inclined to return to their ordinary course, and to abide by the laws marking their natural progress and succession. But this hope proved to be fallacious; for the like vicissitudes and the like changes have been experienced, more or less, from the above period to the present day (1818), there being hardly an instance known of a visitation of the epidemic without its being accompanied, preceded, or followed by changes in the weather or the seasons. In fact, the disease, to quote the words of another observer (and the remark has been made by most persons who have expressed any opinion on the subject), has never appeared in India during that portion of the year usually characterized by clear and severe weather, without producing some change. We thus see that there was not only a remarkable coincidence, as the writer of the Bengal report remarks, between the extraordinary irregularities manifested throughout India in 1816 and 1817, and the rise of the epidemics, but also that its subsequent abatements and revivals were accompanied by similar vicissitudes."

It will be readily conceived that amongst a semi-barbarous people, such as those who inhabit India, a most disastrous and appalling effect would be produced by the destruction of their crops. Famine would so reduce their corporeal powers as to cause them to be ready victims to pestilential disease. There is no account of cholera having prevailed during the drought; but it began some time after the wet weather had been established. If an intelligent observer had been present to discover whether the disease had appeared, or assumed greater malignity, about the time that the rain began to evaporate, it would have been more satisfactory, as then there would be less necessity for assumption. The vicissitudes of the elements, independently of volcanic action, were sufficient to produce a great effect on the human body—a powerful effect on its electric condition. During the drought in 1816, there is no account of the prevalence of any disease. The surface would then be dry as a desert, and, being free from evaporation, there would be no sinking of the electric tension, and consequently no disease arising from this cause. But for the destruction of vegetation in 1816 by the drought, there would not have been the famine, and consequent debility of the people, producing a predisposition to epidemic disease.

About the time that cholera appeared in Egypt in 1821, there were observed, in the atmosphere, certain unusual appearances, which were considered to have some connexion with the cause of cholera. Mr. Parkin mentions, that "the apothecary-in-chief of the hospital in Cairo stated, in a letter addressed to the editors of one of the French journals,* that the sky on the approach of cholera to that city, and for some days before, produced a feeling of horror, from the peculiar appearance of the sun; the rays of light being observed, although there was not a cloud. All the inhabitants of Cairo experienced, at this period, adds the above writer, indisposition, as want of appetite, indigestions, flatulence, weight in the head, slight diarrhœa, weakness in the limbs, &c.—symptoms which in the great majority of cases were the forerunners of cholera itself. Dr. Hedenhof, also, the Swedish savant, in a letter published in the *St. Petersburg Journal*, states, that all the East (Egypt, Asia Minor, the Archipelago, Turkey, &c.) had been, during the preceding months, a prey to influenza, accompanied by gastric symptoms." The appearance of the sun would be produced in no other way than by a peculiar state of the vapour that existed in the atmosphere at the time. This might be over-saturation of the air with moisture, and the temperature so elevated as to hinder its partial condensation into a cloud. The indisposition, the inappetence, and other gastric derangements and general illness experienced by many people at that time, may have been the result of the good conducting power of the moist air, and other bodies with which they might be in contact, especially the soil, which, if in a wet condition, would have a powerfully abstracting influence. Different people have observed different appearances in the atmosphere, connected with moisture in the air, which have been conceived to be precursors of cholera. "The

* Page 139.

appearance of a fixed cloud—a phenomena," says Mr. Jameson, "which has frequently been observed to attend all epidemics or plagues, was also remarked in Calcutta. *To the experienced eye it clearly foreboded*, whenever observed, *the return of cholera.*"

The fogs mentioned further on in this writer's work, as having been almost invariably contemporary with pestilence, point out that the air must have been in a very moist condition, which moisture must have been the result of evaporation, and consequent disturbance of electric tension. At page 173, it is stated that "great fogs or mists, causing extraordinary darkness, have occurred in every age, and have almost invariably been contemporary with pestilence. Thus the plague of Egypt, in Pharoah's time, was attended with darkness; as was also that in Rome, A.D. 252 and 746. In the plague which desolated Rome, B.C. 296, there was also a remarkable darkness, under favour of which the Saninites attacked the Roman lines. We also hear of the same phenomenon during the prevalence of the black death of the fourteenth century; for the greater number of writers speak of the thick, stinking mist which accompanied the march of this plague:—'A dense and awful fog,' says one writer, 'was seen in the heavens, rising in the east, and descending upon Italy.'

"Again: On the first appearance of cholera at Dantzic, on the 27th of May, there was a very unusual, dense mist; and it became, accordingly, dark long before sunset. It was commonly reported, said Dr. Hanrick, by many persons who were abroad, that the mist had a peculiar, disagreeable smell and taste, so that those exposed to its influence were forced to wash their mouth with water. A similar mist appeared just before the first appearance of the disease in Rheimfelt, and again in Dantzic on the eighth of June following. I have heard, continues the above writer, this fact of the occurrence of mists with the first appearance of cholera stated by several, and Dr. Barchewity obtained written statements of it by conscientious and intelligent observers, so important did he deem it."

In the early times, both before and after the commencement of the Christian era, there were, as described by various writers, certain appearances that gave indication of the presence of moisture, when pestilential diseases prevailed. Although no mention is made of the previous existence of rains, or the vicinity of marshes, there may have been both rains and marshes, as the people at that time may not have known to trace the origin of fogs and dews to the moisture in the air, which is the result of evaporation from the rains and the wet soil. Hippocrates certainly traced the existence of moisture in the air to its proper source, and noticed also that epidemic disease was concomitant with moist air and the vicinity of marshes; but his opinion could not be so extensively known at that time as to influence the minds of medical practitioners at his day. The stink of the mist mentioned above may have been an emanation from the soil, or the result of that hastily formed vegetable product, called mildew; and in the low condition of electric tension, in which a locality must be when robbed of its electricity by a long-continued evaporating process, the vegetable may be deteriorated. Its career in the growing process may be arrested, and instead of adding to its bulk by the deposition of the necessary constituents, the vigour of the plant being withdrawn, it can no longer retain its elements, but permits their escape; and hence, possibly, the disagreeably fetid emanations.

There is no good reason for believing that the lower animals should not suffer, as well as man, from a negative condition of the soil, as their organization is nearly the same as that of man. They are, however, better supplied by nature with a non-conducting material to cover them; and many of the animals have hoofs on their feet, which are of a non-conducting character. But when the soil on which they stand is very far sunk into a negative condition, it will readily abstract electricity from them, if they present a large surface of the body to its influence, such as they would do by lying down.

The reason why decomposition goes on so rapidly in marshy and other unwholesome localities may arise in this way: the highly negative condition in which the decomposing body is placed has a powerful effect on the electricity which binds the primary constituents together, and these primary bodies are liberated, and fly off, or are deposited, according to their specific gravity.

In an editorial article in a number of the *Medical Times* for 1847, the editor, in taking a survey of the course of cholera, mentions some circumstances which attended the progress of this disease in India. Of all the meteorological phenomena found to attend this pestilential disease, none is so constant as moisture, and cholera is found to prevail in those situations which give most facilities for the development of moisture. The editor states, that Mr. Jameson says, "In the ground of the encampment in which the disease prevailed most, the soil was low and moist; the water was foul, stagnant, and of brackish quality, and everywhere not more than two or three feet from the surface of the earth; and the vicinity abounded in animal and vegetable putrified matter; whereas, at Erich, where the army regained its health, the situation was high and salubrious, and the water clear and pure from a running stream." * The lowness and moisture of the soil had more to do with the cause of the disease than the brackishness of the water: the water in the subsoil, when heated during the day, produces active evaporation, and counteracts the benefit of the heat of the sun; and at night, when this heat is withdrawn, the continued evaporation still further causes low tension, thereby abstracting and weakening the nervous power. The locality, at Erich, to which the army was removed, was superior to the other, only in respect of the superior height and dryness which seemed to be peculiar to it, and without any reference to the clearness or purity of the water in the running stream. The evaporation would be very small in amount, and there would be little or no abstraction of nervous power from the persons of the soldiers. In the paragraph immediately following the one quoted above, the editor adverts to the fact that cholera has a tendency to spread along the banks of rivers. He says:—

"A most distinctive feature of cholera is its tendency to spread along the banks of rivers, inde-

* Medical Times, vol. xvii. p. 6.

pendently of human intercourse. It is not the mere moisture which aids the development, as the poison often remains close to the bank and does not attack the crews of ships lying at a distance; or it passes along one bank without touching the other, although free intercourse goes on, and then, suddenly crossing the river, traverses in an opposite direction the bank hitherto untouched. When it enters a town, it selects the lowest and dampest quarters for its attacks. This was the case in India, Persia, Russia, Hungary, Prussia, and England. Jungle or marshy country, however, by itself, is not always the most favourable for its development. The returns, taken from tabular statements, show that the greatest number of attacks have occurred on cotton soil, which is described as open country, nearly one-third of the whole on the banks of rivers, and one-half within five miles of them. It does not follow, however, that cholera will not ascend hills, although they enjoy a much greater immunity than the plains. For the first three years in India, the Himalayas resisted its progress. It afterward attacked the towns on the lower plateau, and it is a singular circumstance, which after-observation has confirmed, that the per-centage of attacks to the number of inhabitants was much less than in the lower regions, while the fatality was exceedingly great. Cases of cholera have been never known to occur at an altitude of more than 6000 feet above the level of the sea. Dry sandy soils are unfavourable to its development, but are not exempt; this was witnessed both in Arabia and India."

That cholera sometimes leaves one bank of a river, and takes the other, is no argument against the principle that moisture aids its development. Nothing is more common, in these warm countries, than that one bank of a river may be high and dry, and the other low and marshy. There is no weight in the argument, that ships come with impunity near a malarious shore, as the ships are made of wood, and, consequently, the people in them are nearly insulated, and not exposed to have their energies weakened by the same abstracting influences which are in operation on those who remain on the damp land. It is easily understood, on the principles here advocated, why the lowest and dampest part of a town will be the first attacked by cholera. The cotton soil is no way injurious, except in so far as it necessarily contains a good deal of moisture, for the cultivation of the cotton. In consequence of the amount of water, the evaporation will be copious, and it will reduce the electric tension of the locality, which will act unfavourably on those exposed to its agency. The reason why cholera does not ascend the hills is, just that the same conditions which cause it in the plains do not exist there. On the hills, there is less opportunity for the formation of marshes, or for a large wet surface being presented for evaporation. The water, descending from the hills above, may have been arrested and detained in the lower plateau; and a swamp, or its equivalent, a wet soil, thus formed, would, by reducing the electric tension, cause the cases which appeared on the mountain plain referred to. One reason that cholera has not reached higher than 6000 feet above the level of the sea may be, that above this height the temperature is never so high as at lower levels, and the inclined surface of the mountain would give no facility for the retention of the water necessary to cause a moist atmosphere. Dry sandy soils are unfavourable to the development of this pestilence, and, if there be no moist winds blowing over the dry lands, they ought to be altogether exempt from cholera. In many places, there are sandy plains apparently dry, but which contain, within a short distance from the surface, a large quantity of water, causing a large amount of evaporation, when the surface is acted on by the vertical rays of the sun. There must be some circumstance of this kind, unnoticed by the observers, to account for what is contrary to all experience in other situations.

The editor goes on to remark, that "the humidity of the atmosphere, some have thought, has been favourable to its diffusion. The outbreak of the disease in the provinces of Chittagong, Behar, Dhacca, and Sylket, was preceded and attended by unusual floods in Bengal. The seasons in 1816 and 1817 were, indeed, so remarkable as to have attracted the notice of every one, and to have formed the topic of common conversation. During the progress through India, the outbreak of the disease in almost every place was attended by phenomena similar to those which marked its primary appearance. In Europe the same thing was noticed. Jannishen, of Dresden, decided that the virus had a peculiar affinity for moisture. Baumgantner, on the other hand, could trace no hygrometrical alterations during its prevalence. In Russia, it broke out in two or three places, when the thermometer was 20° Fah., and when the air must have been nearly dry. In India it sometimes appears at the commencement of the monsoon; occasionally, however, a very heavy fall of rain checks it. Moisture, of itself, is not powerful in spreading the disease, as we find it retarded by seas and broad rivers. Yet moisture, after all, may be one of the conditions necessary to constitute the peculiar state of the air required for its development." *

Not only do some, but the greater number of writers on diseases of warm countries, believe that humidity has to do with the origin and propagation of this pestilence. At the first appearance of cholera, in the present century, in India, there was a wetter condition of the weather than had been known for a long time previously. In consequence of the great inundations, the Indian rivers overflowed their banks, and covered immense tracts of land. In such a climate as that of India, this produced a large quantity of vapour in the atmosphere, which would make injurious abstractions of nervous power from those who were under its influence. The reason why cases may occur in frosty weather, and in a Russian winter, may be the following:—the particular situation, affected with cholera at a freezing temperature, may be operated on by some of the occult influences which sometimes act on the surface, such as the volcanic. It is stated, that at Rome there is an intensifying of disease for some time before an eruption of the neighbouring volcanic mountain. Such an influence will reduce the electric tension of the place in spite

* Page 7.

of the protecting operation of such a cold temperature, as is above represented. Moreover, the Russian serfs are not the best fed and clad, among the various races of men, and they are known to be filthy and careless in their habits. They most likely have damp floors, from which the heat of a winter fire must cause an evaporation, as from a little marsh, and this, with the probable operation of the subterranean agency, will detract the nervous power from people so situated.

There is no reason to suppose that moisture does not produce disease, because it is apparently retarded by seas and rivers. The air over seas and rivers is often drier than that over the land, as, when the land is thoroughly wetted, the evaporation from it, when acted on by a vertical sun, is greatly more voluminous than from the surface of the sea or rivers.

Mr. Thom, a surgeon in the army, has a series of papers in the *Medical Times* for 1848,* in which he describes the attack of cholera on a portion of Her Majesty's forces, while at Kurrachee in India. After discussing the circumstances connected with the attack, the rapidity of the spread of the disease, the difficulty of finding proper accommodation for the sick, &c., he mentions some facts which he considers to be connected with the cause of the disease. He says, "The atmospheric causes to which I refer are, high temperature, associated with a degree of humidity of the atmosphere approaching to saturation, assisted by a decrease in the pressure of the air and diminished proportion of oxygen, such as belongs to the hot season in India, which act on the

* Medical Times, vol. xvii. p. 328.

human frame with greater intensity when they suddenly succeed a dry and opposite condition of the atmosphere." The great humidity of the atmosphere approaching to saturation indicates a great amount of evaporation, which, on being raised from the earth, draws off its electricity, places it in a negative condition, and tends to abstract the nervous power, exhaust the vital energies of the system, and predispose to attacks of pestilential disease. It is not so easy to understand how the diminished quantity of oxygen in the moist air could operate so deleteriously, since the air is as much expanded by temperature in its dry state as when it is wet, and if this condition of the oxygen of the air be injurious because of its mere expansion, it will be pretty uniformly so in India, where the temperature is almost always high.

In another paragraph of this paper, Mr. Thom states, that cholera "will be found to prevail with greater intensity and extensive diffusion at the periods and places where, after dry winds, there is high temperature, and the air is charged with vapour, and the winds weak or checked by natural obstacles.

"*Certain seasons favourable to its development.*—Thus it is almost universally found that the season or state of the atmosphere which is most favourable to the development of cholera is that which precedes the approach of, or ushers in, the S.W. monsoon, all over India and the neighbouring parts of Southern Asia; in fact, that after the dry N.E. winds of the cold season, followed by the great heats of the early months of summer, the human frame becomes susceptible of a peculiar change incidental to a more or less rapid succession of the estival or moist winds and heavy rains, during which a choleric diathesis is established, and indicated by anorexia, gastric irritation, and tendency to diarrhœa, &c.; and spasmodic cholera will be displayed in a few cases, perhaps, or more generally. As the wet monsoon sets in more or less early or rapid in different seasons, and varies greatly in strength as well as in the deposition of vapour over the diversified regions of India, so also must its effects on the human body be equally subjected to modifications, even without reference to the concomitant circumstances which influence the progress of all diseases."

In this paragraph, Mr. Thom associates the prevalence of cholera with moist winds and heavy rains, during which there seems first to be a predisposition to the disease, as Mr. Thom states that a choleric diathesis is established, as exhibited in the gastric derangements which are frequently found when the moist winds prevail. It is improbable that the nervous power is exhausted all at once. It would require a very strong exercise of the mischievous agency to have such a suddenly debilitating effect on the animal body. The abstracting process will have a certain gradation, and in cholera it is in the gastric organs that these premonitions are most likely to appear. Mr. Thom clearly considers, that it is the wetness of the monsoon which is the principal agency in causing the evil. Other circumstances and agencies merely modify the evil effects of the wetness of the monsoon. He next makes an estimate of the effects of the dry wind.

In another part of the same paper, he states, that "Every one almost knows, theoretically or practically, the effects of such a climate. The dryness of the air facilitates evaporation, so that, by the increased activity of the cutaneous and bronchial secretions, the body is relieved of the superabundant fluid, and its comparative coolness (50° or 60°, instead of 90° or 100°) gives tone to the system and braces the nerves. It is said to be *pure*, because it is dry; and as we know that air contains more oxygen in a given volume at a low than a high temperature, it is more exhilarating and fitter for the purpose of respiration. This is also increased by the absence of moisture in the atmosphere, which displaces the particles of air according to the degree of its elasticity. The result is, that in healthy subjects, free from organic disease, the dry season of the year is productive of cheerful feelings, increased strength and activity."

The dry state of the air, besides increasing the activity of the bronchial and cutaneous secretions, prevents the escape of electricity from the body, as air in its dry state is a bad conductor of electricity; and when it is thoroughly dry, the nervous system is in its most vigorous state; and this accounts for the cheerful feelings, increased strength and activity, which are found to exist among the people in this dry condition of the air. Even when the temperature becomes very much elevated, so long as it keeps dry, there is still an absence of any symptoms of pestilential disease.

Further on in his article, Mr. Thom states, that "No sooner has the sun re-crossed from the southern into the northern hemisphere, and approaches the tropic of Cancer, than a series of interesting changes in the climate of India begin to be experienced. At first the peninsula and central regions begin to acquire a high temperature and give rise to new movements of the air, called 'hot winds,' severely felt at certain places near the deserts; but as these currents are dry, they are not found, either in this or any other country, to be unhealthy, that is, in a remarkable degree, and, although productive of certain febrile and some grave cerebral affections, yet they are free from other and still more severe and numerous diseases peculiar to an opposite state of the air."

When the air is so continuously hot, the evolution of caloric, which is continually going on in a healthy state of the body, will be prevented, and the redundancy of heat must cause discomfort, more especially if large quantities of nourishing viands are taken, by which the internal elimination of electricity will be increased. On the contrary, when the air is humid, and at the same time of high temperature, the circumstances are very much altered. In place of the discomfort of a large quantity of caloric, there is the uncomfortable experience of the loss of corporeal vigour. The quantity of vapour which the air contained at Kurrachee, during the prevalence of cholera, was very little below that of saturation, the dew point being 83° at night, and 86° during the day.* Mr. Thom says, further, "When the air is charged with

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vapour to within a few degrees of saturation, it will not receive more; evaporation is almost at a stand, and, as far as the human body is concerned, the secretion of the skin is checked and rests on the body, and produces that oppressive, muggy feeling, as if the clothes were sticking to the body, and sense of langour, which is experienced on such occasions. Now, this is exactly the state of the air and human body at the setting in, and during the continuance of, the S. W. monsoon.

"(Noxious agency of humid air on the skin), *especially in hot seasons or climates.*—The effects of winds holding aqueous vapour in solution, even in a cold climate or season, is most injurious to the health of man, of animals, and of certain vegetables; but how much more so must it be in hot climates!" Although the secretions of the skin be interrupted when the air is at the point of saturation, yet the conducting power of the moist air will operate on the body and abstract the nervous power; and thus the oppression and sense of langour which are felt when the air is in a wet condition may be accounted for.

In another paragraph, he states that if the moist air be kept in circulation, the evil consequences attending it are in some degree modified. His words are:—"A hot, humid atmosphere, if kept in constant circulation by a strong wind, may not always produce its full effect in a hot country; for, although it should be near the point of saturation, and evaporation is slow and limited, yet, by the rapid change of the layers next the skin, the removal of perspiration is greatly accelerated. But a still and stagnant state of such air will have an opposite effect, and give rise to the most serious maladies, originating in congestion, such as cholera. This has been remarkably the case at Kurrachee. In 1845, a strong, cool, and cloudy, although humid, monsoon unceasingly prevailed all summer, while, in 1846, the heat was much greater, the wind light and unsettled, often marked by calms of two or three days; and in such a condition of the atmosphere did cholera break out."

The advantage of the air in motion over that which is still, may depend on dry wind having been mixed with the moist air, and thereby lessening the proportion of moisture in the air. When the air is in motion, it is unknown how far, or from what region, it has come. It may have come over a dry, arid country, and be consequently dry; and if this dry air is mixed with the moist air, it will modify very much the amount of its moisture, and it may be in this way that a moist wind in motion is less injurious than air at rest.

In another part of his report, Mr. Thom mentions the comparative effects of dry and moist air on a party of soldiers who were going down the river Indus. He says, "Now, it is a curions fact that the influence of the sea-breeze is seldom felt higher than Sehwan; and I can well remember, in descending the Indus, in April, that we did not meet this till near Hydrabad, after which we encountered a westerly wind of great strength and steadiness, as far as Tatta, where cholera often prevails. The effects of this wind on our men, cooped up in steamers, and coming down from the dry air of Upper Scinde, was by no means unlike mild attacks of cholera; and, on board one of the vessels, the sudden appearance of many cases of diarrhœa in one night led them to apprehend an outbreak of the disease in a grave form. Had our men been long exposed to this, I have no doubt such would have been the case."

There is here no complaint of any bad effects of the cooping up of the men in the steamers whilst they were in the dry air; it was only when they came into the moist air that they became ill, and so sudden was the effect that in one night many were affected with diarrhœa. It was evidently the moisture of the air which caused the illness of the soldiers, because there were no complaints till they came under the influence of the moisture. There had been a certain amount of injury done—a certain abstraction of nervous power sustained—and all this during the short time that they were exposed to the malign influence; but it was enough to cause an attack of cholera, and, if the men had continued sufficiently long exposed to it, there is every probability that the more severe complaint would have been the result—realizing Mr. Thom's fears.

At a later period, in the 138th number of the *Medical Times and Gazette*, Mr. Thom gives the following account of a sharp attack of cholera which partially affected a party of men under his charge. He says, "While [the 86th regiment was] landing in the afternoon, one boat's load of men, on their way from the steamer to the landing-place, were exposed to a shower which completely drenched them, and, in this condition, they had to remain till they landed and marched up to join their comrades in the town barracks. It was known that many of these men did not change their clothes till they went to bed, so reckless and thoughtless are soldiers on these points. About twelve o'clock that night, a messenger from the hospital came to tell me that 'the men were coming in very fast from the town barracks with cholera.' Between midnight and next morning, five or six cases were admitted, and several more with diarrhœa, cramp, &c., but none of the worst symptoms, as collapse, &c. Having an opportunity of using iced water, we were more than usually successful in quieting the stomach and soothing the general distress.

"On inquiry next day, I found that *every case* was in men who had been wetted in the act of disembarking. They were all seized about two or three hours after getting into bed. The rest of the detachment, who had come from Kurrachee in the same steamer, who slept in the same room, had, in *no one instance*, a sign even of cholera. Another detachment had arrived a few days before by another vessel, but they, also, had a complete immunity from cholera. In fact, all had been under like circumstances at Kurrachee, and on the passage down, belonging to the same regiment, and living in the closest intercourse, except that about thirty men *were drenched with rain, and among these the cases of cholera occurred.* . . . . . . There was no reason to suppose that the men who accidentally stepped into a boat which had landed the rest of their comrades, had anything except the wetting peculiar to themselves from the rest of the regiment."

It will be observed that a portion only of those who got wetted allowed their clothes to remain and dry on them, and it was amongst them that the cases appeared. As in other classes of men, so in the soldiers above referred to, there have been individual specimens of the greater susceptibility to disease, of one more than another. Those who got wetted and did not take symptoms of cholera had better constitutions than the others—they had better resisting powers—had those vital operations in vigorous action which supply nervous power. Strong and vigorous as those may have been who made no complaint, it is highly probable that every one who allowed his clothes to dry on him would be less or more injured, but not so much as to induce him to make formal complaint. The cause of this attack upon the soldiers was evidently connected with the wetting of the clothes, as none of the others were affected. There was here no difficulty about malaria; there is no mention made of vegetable or animal decomposition; there was merely the water in the men's clothes, and the consequent drying process whilst on the persons of the soldiers. Now, the electricity withdrawn from the soldiers by this operation was that which was evolved during the vital processes for the purpose of supplying nervous energy; and so jealous is nature about securing a sufficient supply of this vital element, that a much greater quantity is evolved than is required for keeping up nervous energy; but, in this case, the abstraction exceeded what the system could spare, and hence the disease.

In the Parliamentary Report from which extracts have already been made, Mr. Thom gives the following account of the state of the weather during cholera, in June, and its effects on the system. He says, "The climate of Kurrachee, during the few weeks preceding the appearance of cholera among the troops, was characterized by several peculiarities different from those which generally belong to all hot countries and seasons, perhaps merely so by their presence being in an excessive degree. First, the temperature was unusually high, being 90° to 92° in the daytime and 86° at night, in good houses; and, in the tents of our soldiers, it rose to 96°, 98°, and 104°, as indicated by a thermometer suspended on a central pole, five feet from the ground, and in a thorough draught between the doors. Secondly, the quantity of moisture in the atmosphere was greater than I ever saw it before in any part of the world, or at any season, the dew-point being at 83°, and the thermometer, in the shade, at 93°, the lowest range: even this gives 12·19 grains of vapour in each cubic foot of air. The mean heat in the twenty-four hours was such as to suspend an unusually large proportion of vapour in the air, always *near*, but rarely or never reaching, the point of deposition. Even at the equator, with the sun overhead, I never saw the point of deposition above 78°. The third and, perhaps, most important circumstance worthy of notice, in connexion with the other two, was the light, weak, unsteady winds or calms which prevailed in the early part of June. Now, this is exactly the reverse of what ordinarily happens. In the last two years, the months of June and July were remarkable for the strong, steady, and cool winds, and overcast sky, which have given so favourable a character to the climate of Kurrachee during the hot months. It also appears that the quantity of rain which fell during the prevalence of cholera was much beyond anything that had occurred for a long time before; at least, it surprised the European officers who have been here for three or four years. The state of the barometer I cannot give, but it must have been low.

"The effect of all this on the bodily feelings of every one, even the older residents in India, may more easily be conceived than described. There was a sense of langour and oppression, a stifling feeling about the respiration, and inability to undergo the slightest fatigue without extreme exhaustion. It was impossible to sleep at night, yet during the day the tendency to be overcome by a torpid sort of sleep was universally complained of; the body was bathed in perspiration, and the skin was corrugated and thickened as if it had been immersed for a long time in water. The slightest clothing could hardly be borne, or anything that arrested the free communication between the skin and the air. Hence every one was forced to seek the open air out of doors, or some place where the weak breezes were turned into a sharp draught, and it was a luxury of no common kind to have a punkah. In fact, for ten days before the predictions were unhappily fulfilled, it was a common remark among 'the old hands' that it was 'regular cholera weather.' At this moment (14th October), the thermometer is as high as it was during the cholera, being 90° to 92° in houses, and 100° in tents, in the middle of the day. Yet we feel fresh, elastic, and free from that horrible, undefinable sense of oppression that prevailed in June. Evidently it is not simple temperature, and 'lichen tropicus' has disappeared. But we have a palpable cause of this agreeable change;—*the dew-point is at* 72° *instead of* 83°, and the evaporation is now, even in a *calm*, more rapid than it was in a fresh breeze in June."

The author considers that the high temperature and the large quantites of moisture had to do with the production of the disease. There was more moisture in the air than at any other period observed by Mr. Thom. The languor and oppression, the stifling at the chest, the nervous prostration, the extreme exhaustion, were all referrible to the abstraction of nervous power, produced by the good conducting power of the moist air. What better preparatory process for this severe pestilence than the vital prostration produced by the high conducting power of an atmosphere laden with moisture?

In a lecture on the diffusion of the Asiatic cholera, and the influence of rivers upon its propagation,* Mr. Ross states that "the progress of the epidemic along the banks of rivers was considered one of the most mysterious problems connected with the malady when it first attracted the attention of European physicians in the years 1831 and 1832. It was stated that the epidemic generally advanced against the stream, as was instanced in the cases of the Ganges, in Asia, and the Volga, in Europe; and that, in its course up a river, it would, in the most inexplicable manner, keep either to one side of the stream and leave the other wholly untouched, or it would suddenly pass from a town on the left bank to a town on the right, and reappear as unexpectedly at some distant town on the left bank, leaving the intermediate towns on that bank unvisited. These erratic freaks caused universal astonishment, but, unfortunately, they did not induce inquiry, and the facts themselves were sometimes denied. Dr. Tytler asserted that the epidemic showed no such electric

* Medical Times, vol. xix. p. 50.

power in India, and that, as regarded that country, the statement was untrue. Nobody refuted him. Still, however, these observations might have taken place without the exercise of any mysterious power by this agent. All the great towns on the Ganges and the Jumna, for example, the region of its greatest havoc, are on the right bank; was it then so very extraordinary that the disease should have preponderated on that side of those rivers? Benares is the only great town on the left bank of the Ganges. In India, I have remarked, by referring to the map, that nearly the whole of the towns, in which the visitations of the epidemic were most severely felt, were situated either on the sea or on the banks of rivers, and, in the latter case, almost invariably on the right bank. Is the right bank of rivers, in Northern Hindostan, the more suitable one for human settlements in consequence of its alluvial soil and superior fertility? On the Godavery, in the Deccan, all the towns are on the left bank; there is not one on the right. Why is this? Is it a consequence of nationality, or the superior adaptability of the soil to cultivation? These are questions for the natural historian to answer.

"It is probable, however, that the cause which accumulates settlements on the one bank or the other, by preference, also influenced the mortality of the epidemic; and this influence might be altogether distinct from the single fact of the actual herding of human beings together in large masses. It is the influence of locality. With respect to the cholera advancing against the stream, it might be said that if it travelled up the Ganges, it swept down the Nerbudda; and if it went up the Volga, it came down the Don and the Rhine. The cholera will be found especially to rage in large towns, and large towns will be generally situated on the banks of rivers; hence the cholera will be found in these situations. In Hindostan, which abounds in rivers, through whose means all traffic is conducted, this is almost an invariable rule. But Persia is differently situated; it is covered with deserts of sand, and internal communication is conducted by means of caravans; its great towns, Ispahan and Teheran, are in the midst of these sandy plains; and though the cholera scourged the towns on the coast of the Persian Gulf and in the delta of the Euphrates, Ispahan was visited mildly, and Teheran escaped altogether. This latter town happens to be singularly situated in the midst of a salt, moist plain, near the foot of the Elborez mountains. Did it owe its immunity to this cause? Yet the ocean is sufficiently salt, and did not guarantee an immunity to Bushier, where there was a tremendous sacrifice of life; nor did the towns in the neighbourhood of the salt-mines of Europe escape. The long immunity of Teheran was the great theme of the contagionists in 1832, who declared that the King of Persia saved his capital from the ravages of cholera, by forbidding a caravan coming from an infected district to approach within forty leagues of the city. One word of the King of Persia could effect a greater prodigy than an investing army at Berlin. The Persian monarch could command the epidemic to stand still,—a power, fable tells us, that Canute the Great could not over the waves of the sea. This notion may be left to the credulous."

On the principles here advocated, there is no mystery in the fact that cholera and other pestilential diseases are confined for the most part to the banks of rivers; as these diseases luxuriate in moisture, and it is in such circumstances that they may be expected. It is easily explicable, how cholera may go either up or down a river, and how it may take the right or left bank, just in so far as the one presents facilities for evaporation more than the other. The one bank may be higher and drier than the other, and that will be the bank which will escape the disease; whilst this, being low and damp, will form a suitable haunt for its ravages. The very cause which would induce the choice of the side of a river as the habitation of a population, would also present favourable conditions for attracting pestilential diseases. Alluvial soil and a considerable amount of moisture are indispensable for the growth and easy cultivation of vegetation, and if there were *only* the requisite amount of moisture, no injury might arise. But the inundations, to which almost all the Indian rivers are subject, place the towns and cities in the centre of immense collections of water, which, during their subsidence, send up a copious evaporation. This causes a great fluctuation in the electric tension, and produces a very low state in the locality where this process is most active.

Dry deserts in all parts of the world are very little favourable to the spread of cholera. The sandy plains of Persia may have hindered cholera, on its first outbreak, from invading the interior and its capital; but, at a later period, Teheran was visited by the pestilence, which committed great ravages, and caused many of the semi-barbarous inhabitants to leave their habitations. Its salt moist plain did not protect it then. It was even more likely to be exposed to the ravages of this disease on account of its moisture. Ispahan is very differently situated: it is described as being placed in a dry locality, where it seldom rains, and as being very salubrious. In consequence of the general dryness of the earth round this city, it will have little abstracting influence on the animals placed on it, as, for the most part, it will be in a positive condition. The immense mortality at Bushire depended on a different condition of matters. Its situation, on a small isthmus on the border of the Persian Gulf, would expose it to the operation of a vast amount of moisture, which, by its evaporation, would cause a diminution of the vital energies of the people, and predispose them to become the ready victims of this disease.

Mr. Ross quotes from M. Gendrin some facts which are very interesting, and well adapted to throw light on this subject.* He says, "M. Gendrin showed, in his able work on the Cholera of 1832, that the mortality from that epidemic, in particular districts of Paris, bore a direct relation to their contiguity to the river: thus, in those arrondissements lying on the banks of the river, the mortality was 1 in 37·39 inhabitants; in those arrondissements adjacent to the first, 1 in 95; and in those arrondissements remote from the river, 1 in 126·64. This mortality did not appear to M. Gendrin to be at all influenced by the character of the habitations, trades, or pursuits of the persons living in those localities. Poverty or vice, according to him, was

* Med. Times, vol. xix. p. 51.

no aggravation of the disease. Thus, in the third arrondissement, where the houses are high and dirty, and the inhabitants crowded together in squalid masses, but which is remote from the river, only 1 in 226·51 persons died; in the sixth arrondissement, similarly situated, 1 in 146·92; in the fourth arrondissement, one-quarter of which touches the Seine, 1 in 126·01; in the eighth arrondissement, three-quarters of which lie on the river, 1 in 52·71; in the ninth arrondissement, similarly placed, 1 in 18·000; and in the open and spacious Faubourg St. Germain, three quarters of which line the river, 1 in 35·02: thus showing that the mortality was in a general ratio to the proximity of the river to the infected district."

Now, why is it that the population nearest the river, and on the lowest level, have suffered most from the visitations of this disease? This unfortunate peculiarity must depend, in some way or other, upon something connected with the river. As water is the principal body of which the river is composed, it must be this which is the evil agent. It will be found, then, that the habitations nearest the river will, even in the best circumstances, have their foundations damp and cold. The soil on which Paris is built must be more or less porous; and hence it will allow the waters of the Seine to percolate about the foundations of those houses nearest its banks. Another source of dampness is, that the whole of the drainage from the higher quarters of the town must run past these houses, and water may escape from the conduits, and diffuse itself in the soil outside, and thus find its way to the houses. It will also happen that, when it rains, the water from the higher parts of the city will pour down, and keep the lower parts much longer wetted than the upper. The foundation of the walls of the houses must be less or more in contact with the water, keeping them always damp; and this dampness will attract electricity from the upper part of the house, and conduct it to the earth. If the floors of the houses be on the ground, and kept damp, or made of stone, this will be another source by which the vital electricity will be drawn from the people in contact with them. The people on the floors above will be much safer, in so far as they are placed on wood, and are, in this manner, partially insulated; and, if they avoid continued contact with the walls, comparative safety will be insured. There is a striking difference between the mortality of the people residing in the higher parts of the city and that of those who live near the river; and so decided is the difference in those arrondissements in contact with the river, that it cannot be attributed to accident. So much stronger is the mischievous agency which operates near the river, that the squalor, the filth, the vice, and the wretchedness, in a higher part of the city, and at the top of high houses, did not cause the inhabitants to suffer a tithe from the disease, as compared with the people below. Although the degraded portion of the population in the third arrondissement wasted their vital powers by their vicious habits, yet from the accidental circumstance of their being in houses dry at the foundation, and being elevated in these habitations, they enjoyed a comparative immunity from the disease. Here the deteriorating influence of crowding together in large numbers, in small apartments, of breathing over and over again the same vitiated atmosphere, seemed to be comparatively inoperative. The protecting agency of their high and dry position seemed to be more powerful for good than their dissolute habits were influential for evil. In Paris, the lower classes are not so far sunk in wretchedness as the corresponding orders of society in the large towns of England. The Parisians live more temperately, and are seldom so far sunk as to be unable to procure such plain simple diet as is sufficient to maintain their vital powers in vigour. But many amongst the English of this class wear out their vital energies with stimulating drinks, and at a certain stage become unable to procure the barest necessaries of life; and hence the great mortality among the lower orders in this country when attacked by this disease. That lowness of position, and dampness of condition, are causes of insalubrity, is well known to every observer; and the following extract very satisfactorily illustrates this fact:—*

"An epidemic does, indeed, reign, but it is confined principally to the soldiers in the barracks at Fort St. Elmo (Malta), and it is now thought to proceed from effluvia rising from a large drain running through it, and the water which is used for drinking being in a state of decomposition. It is a powerful argument in support of a local epidemic in that fort, and in favour that no cholera exists, that it had not spread for six weeks; and when the corps were removed, on Tuesday,—the 69th occupying quarters vacated by the 44th,—three men died on the following day. It is not unusual, either, to register,

* Med. Times, vol. xix. p. 47.

at this season of the year, many deaths among the soldiers there located; for it is unhealthy, *being below the level of the sea;* and a new wall, lately built, excludes the air to a far greater extent than before. The 7th Fusiliers lost from fifty to sixty men a-week some years ago, when they were in Malta; and the 77th, 88th, and 42nd regiments, when here, and in that fort, had also to deplore the loss of many of their men."

It is difficult to conceive how certain effluvia can produce such an amount of insalubrity as attends this barrack. We find drains of the most offensive character terminating at the very doors of the lower classes, in high situations, and their houses fuming with odours nearly as bad as the worst drain; yet the people continue healthy and robust, though continually exposed to these offensive fumes. The site of this barrack being below the level of the sea, it is not easy to understand how a drain could be effective. The contents of this drain must have spread more or less over the ground, and the fluid emissions allowed to evaporate by the heat of the sun. The hollow in which this barrack is placed must be very wet, as there are often heavy showers in Malta, and the portion of those showers which falls in this hollow must all be raised by evaporation, besides the water which is emitted from the drains. This will subject the place to great variations of electric tension, and reduce the barrack often to a low condition. Three deaths in a party of soldiers, after one day's residence, is an awful mortality, and shows that there must be a powerful instrumentality for evil somewhere in connexion with this barrack. Indeed, in such a climate, there could not have been chosen a more pestiferous situation for the habitation of men. The atmosphere at Malta is very often moist, and frequently so much so as to suspend the dust which rises from the streets, and which alights on the garments of the people like mud. It has been supposed that these so-called mud-showers have something to do with the origin of the diseases which arise on the island.

Mr. Ross takes a different view of the diffusion of the mortality of London, from that taken by M. Gendrin in Paris. He considers that it is more correct to take the ratio of deaths to the whole number of cases, and not to the whole population. The rule for London may be unsuitable for Paris. In the latter city, there is not such a disparity in the relative height between the part of the city which is on one side of the river, and that on the other, as there is between the different parts of London. In London, the portion on the north side of the river is generally much more elevated than that on the south, and, on this account, the method of estimating the number of deaths to cases in cholera would not be correct. On the south side of the Thames, at London, the level is low, and a portion of the ground is described as having been once a marsh. No part of Paris will be found to correspond with this. Paris would be more correctly contrasted with London by leaving out the south side of the Thames altogether. In this view of the case Mr. Ross and M. Gendrin agree. Mr. Ross gives the following account of the proportion of cases to the rest of the population on both sides of the river. He says:—"Of 9,008 cases that occurred in the Metropolis in 1831-2, 4,198 occured on the south side of the river, and 4,810 on the north side, which, by a comparison of the cases with the population on the respective sides of the river, shows that the number of *cases* on the south side in a ratio to that on the north side was nearly 4 to 1, being, respectively, on the north side, 1 case to 236 persons, on the south side 1 to 64." * There is an immense disparity between the number of cases on the one side and those on the other. There have been about four times the number of cases on the south side of the river, proportionately to those that have occurred on the north side. This cannot be an accidental circumstance; it is the result of a law. There are certain localities, in some parts of the world, which are insalubrious, independently either of level or moisture; but, in some of these situations, it has been found that the electric condition is peculiar. That portion of London which is on the south side of the river is in no place more than between four and five feet above high-water mark, and there are large districts which are considerably below it—even six inches lower. Now, it is not surprising to find that a portion of the city, thus situated, is unhealthy. The subsoil on which this portion is placed will be continually less or more saturated with water, and the portion which is below high-water mark cannot fail to be submerged when inundation of the river takes place, and can only with difficulty be drained. On such a surface the houses cannot be thoroughly dry, except, possibly, those apartments which are above the ground-floor. The people who are continually placed over

* Med. Times, vol. xix. p. 51.

such a soil, and nearly connected with the water below, are exposed to a good conducting surface, which acts in withdrawing the inbred electricity—the nervous power—and inducing so much debility as to produce a state of the body which will be easily made diseased.

Mr. Ross, when speaking of the influence of level in connexion with cholera,* puts the following question, and at the same time makes the following reply:—

"Let us now ask ourselves this question, Why is it that there was such an immense majority of cases on the south side of the river? I answer, on account of the low level, and the damp warm atmosphere, and the scandalously bad drainage resulting therefrom, to which I might also add the filthy river water consumed by the inhabitants. A river's bank implies a low level; and if that low level be increased in extent, it augments the difficulty of proper drainage, and encourages that stagnant, close, and moist atmosphere which diminishes the vital energies of the system, and predisposes to disease."

In the above paragraph, Mr. Ross, in answering his own question, states that it is the low level, the consequent improper drainage, and the "close and moist atmosphere, which diminish the vital energies of the system." Mr. Ross considers that the diminishing of the vital energies of the system depends on the facilities for producing moisture in this part of the city. This idea of the effects of moisture on the system is exactly that which is set forth in the principles here advocated. How can the vital

* Med. Times, vol. xix. p. 51.

energies be more effectually diminished than by withdrawing that which supports them? When the human body is surrounded and in contact with such excellent instrumentalities for abstracting that which is the prime agent of life in the animal economy, is it to be wondered at that the vital energies are diminished, and that frequent disease is the consequence?

The same law operates in all countries alike. Lowness of level, and humidity of atmosphere and soil, act in the same manner in all parts of the world. To quote, once more, from Mr. Ross's lecture:—"Look at its ravages in the Sunderbunds, on the delta of the Ganges, in the towns on the rivers of Hindostan; in Bagdad, Bussorah, and Bushier—towns in the delta of the Euphrates and on the Persian Gulf, where the sacrifice of life was enormous, being as much as from one-third to one-sixth of the inhabitants; then, again, in the towns on the delta of the Nile and in Syria, where the mortality was fearful, and has been equally terrific during the present visitation;—in Moscow, situated in a plain; St. Petersburgh, built on piles driven into a marsh, and which is so far below the level as to have been often inundated; and here, too, the havoc during the present visitation has been tremendous. What is true of different districts of one city would doubtless prove true of different cities, as compared the one with the other, if facts had been carefully observed and honestly recorded." *

All those places which have been distinguished by enormous mortality are on low levels. Bushier

* Med. Times, vol. xix. p. 52.

is a town built on a low isthmus, which is sometimes surrounded by the sea. This implies that the tidal fluctuations will frequently leave a wet surface exposed twice a day to the burning sun. St. Petersburgh, built upon a marsh, is in the best position to be continually insalubrious, and occasionally pestiferous. In a warm climate, a city thus situated would be well nigh uninhabitable.

The Report of the Registrar-general corroborates, in a most remarkable manner, the statements of Mr. Ross and M. Gendrin in reference to the influence of level in producing cholera. There can be no suspicion of the facts detailed by this officer, as they are produced from a trustworthy source. There is not the slightest reason to doubt either Mr. Ross or M. Gendrin; but the Registrar-general has data of the most accurate and conclusive description, and no one can question their correctness. There is a great assemblage of data in the Report of the Registrar-general, but that portion of it which relates most closely to our argument is the influence of level as a cause of disease. Indeed, this is a law which operates in every part of the world. The portion of the Report bearing on the influence of locality as a cause of disease will serve to illustrate our position. The following is taken from the *Medico-Chirurgical Review*:—*

"*Influence of locality.*—The influence of locality on cholera was extraordinary, and is well illustrated by the fact that 46,592 of the 53,293 deaths from cholera, in the year 1849, occurred in only 134 out of 623 districts. To put this in other words, 46,592 deaths occurred in an area of 7,839 square

* Medico-Chirurgical Review, July, 1852, p. 51.

miles, on which *four-tenths* of the population dwelt, while only 6,701 deaths occurred on an area of 49,228 square miles, on which dwelt *six-tenths* of the population.

"Eighty-five districts in England escaped the cholera altogether. These districts lie generally high, and are thinly peopled. Their population has scarcely augmented during the last ten years; the average mortality in all, during the ten years, has been very low, viz. 1·75 per cent.

"In seventy-three other districts there was no cholera, but some diarrhœa. In these districts the average annual mortality, for ten years, has been 1·905 per cent., and the population, during that time, has only augmented three per cent.

"The cholera was three times more fatal on the coast than in the interior, and, on further analysis, it appeared that the fatality was greatest in the chief sea-port districts. Thus 26,773 deaths, or *more than half* those of the whole country, occurred in London, Liverpool, Hull, Bristol, Plymouth, Portsmouth, Southampton, and Tynemouth. Setting aside London, the sea districts may be divided into three groups:—

"(a) *Including the large ports.*—Here a dense population is crowded on the low alluvial soil of the mouths of rivers, and the deaths from cholera was as 125 to 10,000 persons living.

"(b) *Including the secondary ports.*—The mortality was as 47 to 10,000 persons living.

"(c) In the other coast districts, which included small ports, often inaccessible to ships, the mortality was only as 15 to 10,000 persons living.

"On comparing more particularly sea-coast and inland districts, it is found that, in forty-seven districts on the river and sea margins, there were eighty-five deaths from cholera in every 10,000 inhabitants; while, in forty-one inland districts, comprising the large towns (except London), whose aggregate population and whose average mortality are both greater than those of the forty-seven coast districts, there were thirty-eight deaths to 10,000 persons living. The fatality in the two groups was, in fact, as $2\frac{1}{4}$ to 1.

"In the rest of the kingdom, after the abstraction of these two groups, the mortality was only 12 in every 10,000 inhabitants.

"The great prevalence of cholera and mortality in the coast districts has always been a strong argument for the contagionist's doctrine, which referred the disease to intercourse with other infected ports. It is, however, extremely probable, if not certain, that too much stress has been laid on this argument, and that the prevalence of mortality in the great ports is due, in great measure, to the low level in which they stand, and to their position on alluvial soil. The influence of elevation on cholera will appear more fully in considering the causes of the mortality in London.

"The *coal districts* suffered considerably, the deaths being forty-six from cholera and thirteen from diarrhœa to 10,000 inhabitants. The *marshy districts* of Lincolnshire and Cambridgeshire suffered very little; North Witchford, Whittlesey, and Wisbeach escaped; so also did some of the marsh districts of Essex and Kent. In the Romney marsh, only one death occurred.

"Geological formation appeared to influence it in some degree; the districts on the Granitic, Silurian, and Devonian systems nearly escaped. Herefordshire, in the old red sandstone, escaped, while Cornwall and part of Devonshire, on the same formation, suffered severely;—still, other circumstances were in play here, and the influence of geographical formation cannot be very great. . . . . .

"*Elevation.*—Of all the causes influencing the spread and the mortality of cholera, none has so great an effect as elevation. This fact, known for a long time, has been worked out by Mr. Farr so perfectly that it may be received like the solution of a mathematical problem. We shall quote, verbatim, as much as possible of Mr. Farr's statements on this point, referring to the book itself for the tables, and for the various proofs and calculations on which they are based.

"The mortality [and, therefore, presumably the prevalence—*Rev.*] from cholera is in the inverse ratio of the elevation. The mortality of the nineteen highest districts was at the rate of 33 in 10,000; and of the nineteen lowest districts, 100 in 10,000. The elevation of the two groups was as 71 to 10 feet above the high-water mark of the Thames, or as 7 to 1, while the mortality was as 1 to 3, or in the inverse ratio. In the two groups of the six districts supplied with the water of the Thames, at Kew and Hammersmith, the mean elevation was 35 and 175 feet, the mortality from cholera 19 and 11 in 10,000. In the two groups of twelve districts supplied with the Thames water between the Waterloo and Battersea Bridges, the mean elevations were $\frac{1}{3}$ foot and 10 feet; the mortality, 168 and 77 in 10,000. In the two groups of twenty districts supplied with the waters of the New River and the sea, the mean elevation was 24 and $59\frac{1}{2}$ feet; the mortality from cholera was 59 and 37. While the effects of the water and of the wealth of the districts are apparent, they do not in this analysis conceal the effects of elevation. Cholera was excessively fatal in all the four districts which lie on a level with, or below, the Trinity high-water mark; it destroyed 144, 161, 164, and 205 in 10,000 inhabitants. In the five districts which lie two to four feet higher, on an average, the mortality was at the rate of 68, 97, 120, 153, and 181 in 10,000. In ten districts, of an elevation of fifty feet and upwards, the mortality from cholera was not higher than 8, 8, 17, 19, 22, 22, 25, 35, 35, and 53 in 10,000. The last mortality occurred in St. Giles', in which the beneficial effect of elevation was neutralized by other causes (pp. 61-2.)

"On further examination, it is evident that, notwithstanding disturbing causes, the mortality from cholera bore a constant relation to the elevation. Thus, on arranging the districts into seven terraces, the first under twenty feet of elevation, the second under forty, the third under sixty, and so on, it is found that, the mortality on the ground under twenty feet being estimated by 1, the mortality of each successive terrace may be represented by $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{5}$, $\frac{1}{6}$; or the mortality on each successive altitude of twenty feet was $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{5}$, $\frac{1}{6}$, &c., of the terrace immediately below it. The highest terrace (340—360 feet) is Hampstead.

Elevation of Districts, in feet.	Number of Terrace from bottom.	Deaths from Cholera in 10,000 Inhabitants.	Calculated Series.
20	1	102	$\frac{102}{1} = 102$
20 — 40	2	65	$\frac{102}{2} = 51$
40 — 60	3	34	$\frac{102}{3} = 34$
60 — 80	5	27	$\frac{102}{4} = 26$
80 — 100	4	22	$\frac{102}{5} = 20$
100 — 120	6	17	$\frac{102}{6} = 17$
340 — 360	18	7	$\frac{102}{18} = 6$

"The greatest discrepancy between the actual and the calculated mortality is at the mean elevation of 20—40 feet; and, on examination, this elevation is found to include the districts of Bethnal-green and Wandsworth, where other disturbing causes combined to heighten the mortality.

"We have already seen that the effect of bad water almost disappears under the permanent influence of elevation. We shall now extract a portion of another table, to show that density of population and over-crowding, which exerts some influence over mortality, has, also, by the side of elevation, comparatively little effect:—

Elevation in feet above Trinity High Water Mark.	Annual Mortality to 10,000 Persons living.		Number of Persons to	
	Cholera. 1849.	All causes. 1834—44.	An Acre.	A House.
Under 20 feet	102	251	74	6.8
20 — 40 „	65	237	105	7.6
40 — 60 „	34	235	184	8.5
68 — 80 „	27	236	152	8.8
80 — 100 „	22	211	44	7.7

"The extraordinary effect of elevation appeared so important that it was thought right to submit the principle to another test, by comparing the elevation and the mortality from cholera of each sub-district. The result entirely confirms the announced law.

"This law of elevation is, perhaps, the most important practical point brought out in the Report, and is well worthy the attention of the authorities of the East India Company; for the fact, though long recognised, has never been so definitely shown before. . . . . . .

"*Influence of general insalubrity of district.*—There is a very constant relation between the mortality from ordinary causes and the density of population. Places generally insalubrious suffered most from cholera. Thus, of the thirty-eight districts into which London is divided, nineteen have a density of 155 persons to an acre, a mean elevation of twenty-six feet, and a mean annual mortality of 268 in 10,000; the mortality from cholera was 84 to 10,000. The nineteen other districts have a density of 57 persons to an acre, an elevation of fifty-five feet, and a mean annual mortality of 212 in 10,000; the mortality from cholera was 48 in 10,000. The facts appear to be, that a low elevation contributes to general insalubrity, as well as to cholera; but that its effect is not so great on other diseases as density of population."*

Locality evidently influences salubrity more by elevation than anything else. It is stated above, that eighty-five districts escaped cholera altogether, and the reason assigned for the immunity of these is their superior height. There are implied in the

* Medical Times, vol. xix. p. 52.

superior elevation, superior dryness, less evaporation, and fewer instrumentalities for exacting nervous power. It is not so much absolute height which causes a situation to be healthful, as it is the summit of a height, since this portion will be always the driest, and consequently the most healthful. Mr. Ross states, that cholera has appeared on the high table-lands of the Himalaya Mountains, but "these table-lands are difficult of drainage, and are often overhung with fogs; and a relatively low level will produce precisely the same mischief, and in the same degree, as an absolutely low level. This is the case with Scinde. A stagnant marsh, 1,000 feet above the level of the sea, would produce ague as quickly as another fifty feet below it." Seringapatam is 2,000 feet above the level of the sea, and, even at this elevation, it is highly insalubrious, just because it has neighbouring marshes. There are high levels — higher than any contemplated in the Registrar-general's report —which have suffered both from cholera and intermittent fever. The high level, then, has nothing to do with the superior healthiness, except in so far as that it secures dryness. There is an island on the African coast, cited in another part of this work, which is little above the level of the sea, and is comparatively healthful, whilst the coast a little way off is highly pestiferous, though, even on this ill-conditioned coast, elevation secured salubrity.

The seventy-three districts which had no cholera, and had a slightly increased mortality, have not their elevation stated, but it is to be presumed that they are a little lower in situation than the eighty-three just mentioned. They seem to be just so far down as to be subjected to a small amount of the morbid influence. It is quite in accordance with what might be anticipated upon the principles here advocated, to find that the lower localities of the country would be a more congenial sphere for the propagation of cholera, and that, just because these low localities present facilities for dampness and evaporation. That which is most likely to favour the accumulation of the number of cases in the more densely peopled regions would be the predisposing causes, dissipation and destitution, which generally prevail among the vicious portion of a large population. Besides the advantage of height and consequent dryness, the pastoral and abstemious habits of a large number of the people in the higher localities will put their systems in the most vigorous action, and in this way enable them to present the best resisting power against the assaults of this disease.

The secondary ports are generally at the mouths of the smaller rivers, or on some accessible portion of a rocky coast. There cannot, on this account, be the same amount (as at the larger seaports) of flat, damp alluvial soil surrounding such places, to produce evaporation, and disturb electric tension; and there is not the same number of people sunk in destitution, or having the characteristics of squalor and misery, which mark those who haunt the lanes and alleys of the cities containing large masses of population.

On this account, there is a much smaller number of deaths from cholera in these secondary ports than in the large ports. But for the high authority of the above report, it would be difficult to credit that the difference of the mortality in the two places would have been so great. The reason why those ports of the coast which are only at times accessible to ships present such a small amount of mortality from cholera, is the greater height (the inaccessibleness of the ports implying a high, bold, rocky coast), which must of necessity be dry, and yield little evaporation.

The increased mortality on the rivers, and at their embouchement, is very marked. Two and a quarter to one is a great disparity, and suggests the operation of a much stronger agency on the rivers and sea margins than in the inland districts. In these latter districts, there are some large cities containing large populations, where there is a great amount of dissipation and destitution, but where, notwithstanding all these predisposing agencies, the mortality is small, compared with that on the rivers and sea margins. On the banks of rivers, and on the alluvial grounds around the seaports, there is a large quantity of water in the soil, which will yield a large amount of evaporation; and this will operate injuriously on all the people who come under its influence.

The other parts of the kingdom included in the report will be composed chiefly of the rural population and the inhabitants of the villages. Some of these villages, which are situated on the banks of rivulets, may be less or more in the circumstances of the towns situated on the larger rivers.

The deductions of the Registrar-general from the facts regarding low level, and its effects in producing cholera, are just those which might have been anticipated from the principles here advanced. The low level of the river, and the alluvial soil, are instrumental for evil only in so far as they secure the presence of water to cause evaporation. The lowest level, if thoroughly dry, and destitute of any unusual conducting agency, would be perfectly salubrious, and as free from cholera as the top of the mountains.

The miners in the coal districts are engaged in a very laborious occupation, breathe a vitiated atmosphere, and are often exposed to become wetted. The hard labour would tend to reduce their nervous power, and the moisture in their clothes would still further diminish their vital energies.

It has been observed that, in those years in which cholera prevailed, there has been a great amount of rain. The rain would fall on the marshes, as well as on other parts of the country, and the water in the marshes might be increased to such an extent as to convert them into lakes, in which condition there would be much less evaporation, and consequently less disturbance of the electric equilibrium of the locality, and less abstraction from the animals subjected to its influence. The living near the marshes may have produced such a state of the system as to have enabled the inhabitants to resist even the different and more powerful cause of cholera. Another reason may be assigned for this exemption of marshy districts, and may in some measure account for it. The people near these marshes will be accustomed to use that kind of hygiene which is most suited to prevent the operation of the endemic influence, and a continuance of this may be useful in resisting the stronger epidemic influence.

The geological formation may have little more influence than that which depends on height, and the primary rocks generally protrude at great elevations. Some ferruginous formations are found to be most influential in causing insalubrity. This might, on our principles, be, *a priori*, suspected of such formations, as iron is a good electric conductor, and will abstract this element from any animal body that is brought in contact with it.

That portion of the report which refers to London is of the most interesting description. It exhibits within London itself the same phenomena, the same laws, which operate all over the country. The elevated portions of the country districts have not been subjected to the scourge of cholera, and the elevated districts of London have been lightly affected. The low levels on the river banks, and the harbours at their outlets to the sea, have all been severely visited; and the river bank, the harbour, and the low levels of London have suffered with four times the intensity, as compared with the more elevated portions of the city.

The reviewer states, that the effect of elevation has been long known. It has been long known in warm countries, but it is the Registrar-general who has made the facts stand out so prominently, in so far as this principle affects this country. It is most striking to find that, by a regular gradation, as ascension is made from the level of the river to the highest parts of the city, the mortality decreases; and the difference between the highest and the lowest is very remarkable. The lowest elevation had a mortality from cholera of 168 to the 10,000, and the highest a mortality only of 7 to the 10,000. This is a difference that must depend on a strongly operating cause; and this cause, in its operation, acts on the inhabitants of London injuriously, just in proportion to the elevation at which they are placed. The evil instrumentality, which operates thus unseen, seems to be unable to ascend elevations, and appears to gravitate to the lower levels of the earth, where it commits its ravages with the greatest virulence. It had been supposed that the debilitated, and the dissipated, and the crowded together, were the normal and legitimate victims of this disease; but it has been made out, by this trustworthy authority, that when these unfortunate classes are placed on a pretty high elevation, they are not followed by the malevolent instrumentality. Persons who are crowded together, who inhale a vitiated atmosphere, and even those who are dissipated, when sufficiently raised above the level of the river, are, in a great measure, secure against an attack of cholera.

There have been many conjectures about what is the remote cause of the pestilential scourge which occasionally spreads over this country; but the report of the Registrar-general has tended to throw more light on the subject than any other document which has appeared for a long period. It points out very clearly the habitudes of this malign agency in the metropolis of this empire. It shows that this disease luxuriates on low levels, in damp swampy haunts; and that, by a regular law, when it travels up, it loses its intensity at every succeeding stage in its ascent. This law, observed by this agency, is not peculiar to London, but is applicable to the country all over, as well as to any other country, and its towns, where their positions are analogous.

Now what evil agency is this which affects so slightly the high elevation, but strikes so fatally on the low levels? The water of London, that which is used in the food and for the drink of the inhabitants, as well as other agencies, have been suspected as the causes of cholera. The effect of the water, as it falls from the clouds on the city, and of that which percolates through the soil from the river at its low levels, has never been taken into account. The effects of the rains, in tropical countries, are very conspicuous, and at once attract attention. The rains which fall in temperate countries are followed by no direct manifestations, and excite little attention. The hidden operations of this element, in temperate climates, are not the less real, because they are not observed. By the application of our principles, an estimate may be made of the part taken by this element in the production of cholera.

The rains which fall on the heights—the highest terraces in London,—after saturating the soil, run down on the terrace below. This lower terrace had its own portion of rain, and now it will be much more wet, and continue longer wet, than the terrace above. Then the next terrace below will have its own portion of rain, and whatever passes off from the two above. Then, the fourth terrace will have all that passes off from those above. This, of necessity, must be more damp than any of the terraces above. In every step downwards the damp, wet condition of the soil will be increased. The water on the surface will always run downwards, and that which is absorbed by the soil, and which percolates into the earth, will keep the subsoil and the surface much longer wet than these higher up. At these low levels, the foundations of the houses will be in a more damp soil, and the floors which are placed close on the earth will be both cold and damp. At the level of the river, there are the rains which fall on the surface, besides a share of all the showers coming down from the terraces above, and also the percolation of water from the river to those on the lowest level, as well as that which, in some places, may be carried up by capillary attraction.

There is here an estimate of the cause and measure of the humidity of the different parts of the city. There is found to be a regular gradation of dampness from the highest to the lowest level; and, if it were possible to examine the state of the ground from the greatest elevation of the city to the river, it would be found that the soil would be damp to a gradually increasing depth, till it came to the lowest level, where the maximum amount of dampness would be reached.

The south side of the river is very unfavourably placed in regard to level, as it is almost all low, and the houses must have their foundations on a damp soil. The ground floors of such buildings will be unhealthy, and will be still more so, if they have stone floors, or any other substance of equal electro-conducting power. What a powerfully depressing effect will be produced on those who are continually exposed to the abstracting influence of stone floors on the lowest level! The damp soil will always have a tendency to conduct electricity from those individuals who are brought and kept in near contact with it.

The data presented in the section of the Registrar-general's report above cited, regarding the influence of elevation on salubrity, coincide with those which have been observed in other parts of the world. But elevation contributes to salubrity only in so far as it secures dryness. In many places in hot countries, where the influence of elevation is more apparent than it is in this country, the low level, when dry, is as salubrious as the summit of a height. It is observed, also, that it is not the absolute height which is of importance, but that it is the summit of a height which is found to be salubrious. The summit, from a physical necessity, must be the driest part of the eminence. For example, in one of the most pestiferous situations in the West Indies, there are two hills, on which were three barracks; two on one hill, and one on the other. The single barrack on the one hill was on the summit, and on the hill where the two were placed, one was on the summit, and the other was 100 feet further down the hill. In the two barracks on the summits of their respective hills, there was scarcely any disease, whilst in the barrack down the hill there were frequently cases of fever. The greater sickness in the barrack on the side of the hill depended on the greater amount of dampness which arose from the rain, that falls on the portion of the hill above, running down.

According to this principle, if the highest elevation in London had been continued into a hill rising behind the city, the disparity between the mortality of the highest district and that of the lowest would not have been so great as it now appears to be;

because the highest district would not be so dry as it is in its present circumstances, as the rain from the hill above would pour down on the upper district, and cause it to be more damp, and consequently less salubrious, than it now is.

In numerous instances in all parts of the world this principle prevails. Now, with regard to London the same law operates, as has been so incontestably made out by the Registrar-general. The highest district in the scale of the report is 360 feet, and it has a mortality from cholera to the extent of seven to the 10,000 of population. The report does not mention whether this is the summit of the elevations around this city. It is striking how regularly the mortality increases in the descent, and how at the bottom the intensity is increased. Now, this gradation of the intensity of the mortality from cholera coincides exactly with what may be expected from the facilities presented by each district (as one goes downwards) for evaporation and moisture. By a law in physics, the highest district must be drier than the next below, and so on, to the lowest. In the highest district, the people will not be exposed to such a negative condition of the objects around them as the people in the district below. The soil, in the district below, must be more wet, and there must be more evaporation, which, in relation to its amount, will exact nervous power from the people in proportion to the strength of the agency operating on them. In every district there will be a great diversity in the ability of the people to bear the exacting operation of those negative influences. The debilitated from any cause will be the first to succumb, as they have least nervous power to spare. A good deal can be spared—without any hazard of their becoming victims to cholera or any other disease—by the robust, whose vital energies are sound, and whose digestive and assimilating organs are vigorous, and actively eliminating nervous power. In every district, on the scale downwards, there will be an increase of moisture and dampness; and the evil effects are at their maximum in the lowest district, where the mortality is the greatest. There, all the evil influences of the higher districts are in greatly aggravated operation. The electric tension of this part of the city will be always very much lower than that of the higher districts, and the disparity will be much increased during rainy weather. As a consequence of the low condition of this unfortunate portion of the city, the people will be less or more subjected to the exacting operation of the negative bodies around them, which will withdraw the vital electricity; and when more is withdrawn than can be safely spared by any individual thus acted on, there will be corporeal derangements; and, if these are sufficiently great, they will produce disease depending on nervous exhaustion.

The next question is, how will these principles apply in the treatment of cholera? If it be admitted that the cause is as here stated, little improvement can be made on the treatment which has been usually followed in the last stages. From the view here taken of the pathology of cholera, it will be discovered whence arises the difficulty of treating it successfully. When the abstracting of the nervous power is going on in any individual case,—that is, what is known in the history and progress of cholera as the premonitory stage,—then is the time to be useful to the patient. At this time, the nervous power is not yet so much exhausted as completely to produce enervation of the capillaries engaged in the vital operations, and assimilation, secretion, and excretion are yet going on, though it may be feebly; and if, at this point, an arrest be put upon further abstraction of the nervous power, then the unfavourable after-consequences may be averted. When this period passes, that is, when the time during which the nervous powers are sufficiently strong has gone by, when the livid colour of the skin announces the evacuation of the serous portion of the blood, and that the clot with some of these bodies, which should have been thown out by excretion, is alone filling the capillary system, there is here great progress made in the disease,—a condition of matters formidable to deal with. And when the cold shrivelled state of the surface, and the cold raw condition of the expired air, intimate that vitality has well nigh fled, there would be nearly as much hope of succeeding in raising a body to life from under the winding sheet, as of recovering a poor cholera patient at this stage of the disease.

The most important object in the treatment of cholera is to secure a patient at the most premonitory stage of the disease. Since it is by a continued and rapid declension of the nervous power that this complaint progresses, and becomes more and more aggravated, it will be a primary object to secure the patient's complete insulation. This may be accomplished by insulating the bed. Indeed, the hair, the feathers, and the blankets, which constitute a good bed, are sufficient insulators; but cholera patients are not always found on couches of this description; and when patients are found on beds of less insulating materials, glass legs may be employed. The benefit of insulation in the treatment of cholera is not merely hypothetical, as it has been already successfully used by various parties in different parts of the world. M. Fourcault made some representations to the Academy of Medicine, on the subject of insulation, in 1848. The following is the account of it in the *Medical Times*:—

"At the sitting of the Academy of Medicine on the 8th ult., M. Fourcault made some observations on the aetiology of cholera. He thought that the cause of this disease must be attributed to the non-equilibration of the atmospherical electricity with the terrestrial magnetic fluid, which is shown by the perturbations of the needle. He, therefore, proposes as one of the means of curing the disease, that patients should be isolated; and he has had constructed for this purpose an appropriate apparatus. M. Fourcault says that, for some time past, electro-magnetic insulation has been employed at the Bicêtre in the treatment of epilepsy; and in Algiers, Dr. Pallas has placed many of his patients on beds supported on glass legs. All recommended a similar plan to be adopted for persons affected with cholera, and they have noticed that the general results are decidedly favourable to this mode of treatment in epidemics. For this purpose the frames of bedsteads ought to be made of non-conductors of electricity, suited to the circumstances of all classes of society. These hygienic precautions are indispensable in the East, where the people sleep in the open air; during the reign of cholera, of plague, of yellow fever, or of dangerous intermittents, these means exercise upon the public health a most beneficial influence. It is not by supposed deleterious emanations that the earth destroys rapidly a number of individuals who sleep abroad during the night, but by the removal of two agents essential to life—caloric and electricity. This doctrine has been already demonstrated by an authenticated number of facts, wrongly interpreted by physicians, who attribute to an imaginary noxious principle the grand source of epidemics. M. Fourcault says, that his experience of the functions of the skin proves that the suppression of the perspiration and the urine is the true cause of the development of cholera in individuals." *

It is difficult to understand how the non-equilibration of the atmospherical electricity with the terrestrial magnetic fluid could operate in producing cholera. M. Fourcault does not state how this electrical condition of the earth and air operates in producing this disease, and does not show the principle on which he recommends insulation. He mentions that insulation has been found beneficial in various forms of disease, but does not explain the *modus operandi* of the application. On the principles here advocated, however, its mode of action is made easily intelligible. It is not easy to understand how insulation operates in improving the condition of patients labouring under epilepsy, unless it be, that in these patients the digestive and assimilating

* Med. Times, vol. xviii. p. 313.

organs act very languidly, and eliminate slowly, and in comparatively small quantity, the vital electricity which is necessary to support the animal functions and operations. The insulation will, in a great measure, prevent the escape of this defective portion which is eliminated by those patients. The experience at the Bicêtre has been corroborated by Dr. Pallas at Algiers. But it is in cholera that insulation is stated to be most useful, as every one is represented as recommending it. The recommendation to have insulated beds in the East is a very necessary one. Indeed, this kind of bed ought to be used both within doors and without, unless the house itself is insulated.

The measures taken by contagionists to avoid pestilential diseases, when they prevail, act beneficially on the principle of insulation. They confine themselves in their dry houses, and do not place themselves in a position to be acted upon by the abstracting agencies which are the cause of the prevailing disease. The insulation would be safe enough, and benefit might accrue to those confined, were they to leave their hiding-places, and snuff the mid-day air, when the soil is in the driest condition. The lives of a great number of our soldiers might be saved, if means were adopted to allow them to have insulated beds in camp, as in no circumstances, except in a desert, or some other place equally dry, is it safe for men to sleep in the open air. The insulation is sometimes effected by the occupant of a house making a trench around the house. This would secure the greater dryness of the building, and place the inmates in a much safer position than those who have no such provision. A fire is also found to be a preservative from these epidemic and pestilential diseases, and it is used in those countries where plague prevails. It effects this object in no other manner than by heating and drying the apartment, and thereby securing its electro-positive condition.

Cholera, plague, and yellow fever would be shorn of half their dangers, if the inhabitants of those countries where these diseases prevail went to their insulated beds immediately after sunset, and did not go abroad till the sun had risen for some time. It is of far more importance to put the inhabitants in a position to avoid a disease, than to cure it when it has actually occurred. It is in this manner that insulation will do most good. In cholera, it is the emptying of the capillaries of the greater part of the serum of the blood, and their being filled with the remaining clot, that constitutes the disease, and the chief difficulty in treating it. How can insulation be expected to restore the fluid part of the blood, and cause the vessels to be filled with a flowing stream of this vital fluid? It is evidently the prevention, if possible, of this disease which is the matter of most importance. M. Fourcault has no faith in the operation of malaria as a cause of disease, but considers that it is by the removal of two agents essential to life—caloric and electricity. If M. Fourcault would admit that caloric and electricity are identical—merely different manifestations of the same element—and that electricity and nervous power are the same, then the explanation of vital phenomena and morbid derangements would be much easier. The suppression of the urine and perspiration is more likely to be the result of diminished nervous energy, by which the actions of the organs of secretion and excretion are paralysed, and hence the cause of the absence of the excretions. It will then be indispensable that every person in those times and places in which cholera prevails, should have his person covered with flannel, or other warm clothing, from neck to heel. He must avoid all over-exertion, which induces fatigue. He must use nourishing and easily digested diet, and take as much rest in bed as circumstances will admit. He must avoid all excesses in eating and drinking, and be careful to be within doors after nightfall, and especially in rainy weather, as far as possible, both during night and day.

For in times of pestilential disease, insulation of the bed is not alone sufficient, but individual insulation also will be required. In pestilential times, there is, according to the principles here set forth, a large abstraction of nervous power, because of the increased negative condition of the earth and objects around. When it is borne in mind that electricity is such an important element in the animal economy—concerned in every vital action there—it will be always proper to watch over and guide the amount of electricity which continually radiates from the body. The leading indications will evidently be to use means to prevent the escape of the vital electricity in such quantities as could not be without injury spared. It is for this purpose that raiment is worn by the human species, and that the lower animals have been covered with feathers and hair. Imperfect protection from over-radiation of vital electricity gives rise to many diseases, and causes that state of the body which, in popular language, is known by "having taken cold." Those textures, then, are best adapted for clothing which protect the body most effectually from the escape of electricity. Woollen clothing, on this ground, is remarkably valuable, and it is very generally used. It is on account of its non-conducting property that it is found so valuable when worn next the skin. It is on account of the good non-conducting property of wool that it was originally made to cover the animals from which it is taken; and it is to secure this very purpose in the human species that it has been appropriated as clothing. Indeed, it is by their non-conducting property that textures are estimated, and chosen to be employed for clothing. Silk, in consequence of possessing this qualification in a high degree, is well adapted for wearing apparel, and it has been extensively used, but principally for showy vestments, and, probably, with little respect to the non-conducting properties in its character. To obtain the full use of silk—to serve the purpose of maintaining the warmth of the body—it ought to be used as an under-garment, just outside the flannels which are next to the skin. Cotton and linen have the non-conducting property in a somewhat inferior degree, but form valuable auxiliaries, and are extensively used.

The external covering which nature has formed for preserving the warmth of the inferior animals gives countenance to the views here entertained. The hair and skin which cover the quadrupeds, the feathers that adorn and protect the fowls, and the skin and cellular substance that surround the body of the human species, are all good non-conductors of electricity. The human being is less carefully protected than the inferior animals; but faculties to acquire knowledge have been bestowed to make him take measures to protect himself. Non-conducting textures have always been selected for clothing, apart from any philosophical consideration, and without reference to the principles here advocated, as they have been found by experience to be the most suitable for protection against the effects of cold, and otherwise conducive to the preservation of health. With the same view, the rude nations of the Arctic regions cover their bodies with the dried skins of their native animals, and the civilized denizens of more temperate regions wear fabrics composed of wool, hair, and silk. This last substance is a body of a highly non-conducting power, and is on this account a useful material for dress. The barbarous natives of the torrid zone can bear no weighty covering* over their ebony shoulders, but they instinctively smear themselves over with grease; and if this were done effectually, they might be protected from the ravages of many tropical diseases. That this is not mere hypothesis will appear from the following fact:—In the *Transactions of the Medical and Physical Society of Bombay* there are accounts given of fever, which had prevailed during several years since 1817; and Mr. Gilders, one of

* "Anointing the skin prevents the excessive evaporation of the fluids of the body, and acts as clothing both in the sun and shade" (Livingstone's 'Africa,' page 246). It is far more likely that the grease used by the natives, with whom Dr. Livingstone came in contact, acted as a good non-conducting application, rather than in preventing the evaporation of the fluids of the body. We find that grease under the skin prevents the giving off of the electricity from the body, and where this is imperfectly supplied by nature, the application outside will be a good substitute.

the members, remarked "that during the whole of this havoc the rains were passing down in torrents, and as the villages are mostly situated on rising grounds or hillocks, while the intermediate spaces were flooded, the whole surface of the country presented the appearance of a sheet of water." It was stated, that at a large establishment, where oils were expressed, and where a great number of natives was employed, whose habits were disgustingly filthy, always having their bodies covered over with grease and oil, there was not a single death. Though fever was cutting down hundreds around them, not one of these men fell from it, nor did they suffer at the time from sickness. There must be some connexion between the oily skins of these workmen and their immunity from a fever which was cutting down so many at their side: the conclusion is irresistible, that the thick layer of fatty matter, which coated their skins, prevented the escape of the imbued electricity, while it was withdrawn from the imperfectly protected surfaces of those who were unconnected with the oil establishment. The water extending on the surface, being shallow, would be easily heated, and the consequent copious evaporation would withdraw the electricity in immense volumes from the surface of the earth, and leave it, for the time being, in a highly negative condition, and the equilibrium, which is always sought by the elements, necessarily causes a detraction from the greatly more positive state of those individuals who were in contact with the negative portion of the earth acted on by the operation of the evaporation. Oil frictions have been used as a protection against plague. The editor of the *Medico-Chirurgical Review*, in a review of the work of Dr. Hennen, states, "Oily inunctions, the crape mask, fumigations, tobacco-leaves between the fingers of the attendant and wrist of the patient. We have little confidence in any of them. The oily inunctions seem to have most facts in their favour." If these oily frictions have been useful in plague, it is fair to suppose that they will be useful in cholera, as the diseases are analogous. It would not be with a view to electric insulation that the oil was used in friction; it would only be from observing the favourable results of its use. In consequence of the absence of any definite notion as to the reason why these oily frictions acted as a means of protection from plague, the frictions would not be so effectually accomplished, and the bodies of the people who feared plague would not be so completely oiled as the grease-workers about the oil-expressing establishment.

With a correct estimate of the pathological condition of a patient in the collapsed stage of cholera—of the state of the circulation, the languid action of the heart, the vitiated clot in the capillaries, and the consequent livid state of the skin, and the irregular muscular action of the preceding cramps, it is most discouraging to enter upon the consideration of the treatment at such a period of the disease. The cramp in cholera may depend on the diminished power of the muscles which act as antagonists to those which are spasmodically affected. Because of the greater power of the flexor muscles, the nerves carrying power to them must be stronger, and the current in larger quantity than that carried to the extensors; and in the process of nervous abstraction if the power be taken from the muscles in equal proportion, it will be first exhausted in the extensors, and then the flexors, being freed from their antagonising muscles, will act independently. And without the steadying action of the extensors, the flexors will go off into violent action, and hence the cramps in cholera.

On the principle that the disease was produced by abstraction of electric power, the leading indication will be, to supply to the patient the very element that has been abstracted from him, and which abstraction has produced the complaint. This will be best accomplished by applying an elevated temperature to the surface of the body, the heat to be uniformly applied and sustained. In Dr. Metcalfe's work on Caloric, there is represented a treatment accidentally adopted, which will meet in a great measure the indication here pointed out.* The following is the statement of the case:—"During the existence of cholera in Germany, the papers gave an account of two salt-boilers who were attacked with the disease, and given over as hopeless by the attending physician. But the superintendent of the establishment, observing that they were extremely cold, resolved on trying the efficacy of putting them into a bath, as hot as the hand could bear. The consequence was, that a few minutes after he placed one of them in the bath, his skin changed from purple to a bright red colour, when he began to take deep inspirations, which increased in frequency as the circulation revived. He soon afterwards recovered his senses, and observed how very delightful his feelings were. The same plan was

* Metcalfe on Caloric, vol. ii. p. 819.

then pursued with the other patient, attended with similar results, and both speedily recovered without any other remedies. All the phenomena of physiology demonstrate the salt-boiler employed the very best possible remedy, by availing himself of the agent or principle on which all the operations of life and health depend."

In the treatment above represented, the indication was completely followed up. The patients were abandoned as hopeless, and the cold condition of the poor, perishing victims prompted a sensible mind to supply what the poor patients required. In doing this, it was supposed that no harm could be done, as the uninitiated naturally considered that heat was what a cold patient required. The expedient is represented as having been completely successful. The hot bath in these cases, and in their condition of collapse, was the very remedy which, on these principles, might be expected to be successful. It was by the loss of their nervous power that the disease was produced at the outset, and a recovery of that power would be most likely to restore the expiring vital energies. The bath, at the temperature represented, was the most hopeful remedy which, in the circumstances, could have been adopted. The heat applied in this way secured its universal application. The morbid effects were spread all over the body. The small capillaries were implicated; then the remedy required to embrace the whole surface. The heat applied at such a temperature would speedily communicate a large quantity of electricity, as the temperature was raised much above the ordinary animal heat. The stimulation of the surface would tend to draw the fluids from the centre of the body, and liquify any of the remaining fluid constituents that may have been left in the circulatory system, and thus assist in establishing the circulation. If in such circumstances the evacuations had continued, sedatives might have been given to arrest the further discharge of the fluids from the body.

Apart from the principles here advocated, two cases are too small a number on which to place confidence for our future guidance in the management of cholera. But there are strong reasons for believing that though twenty cases, or even a much larger number, had been treated in the same manner, a like result would have been obtained. A hot bath can be procured in almost all places, and the application of warm oil round the body would form a good auxiliary to the treatment. To effect this, a proper quantity of oil being raised to the temperature of the soap-boiler's bath, a blanket, or some other equally large woollen cloth, should be soaked in it, and wrapped round the body of the patient, who is afterwards to be covered with other warm blankets, that the high temperature may be longer maintained. The heat may be kept up as long as is necessary by the repetition of the warm oil coverings. Oil is a good retaining, and a bad conducting body.

CHAPTER V.

ON VARIATIONS OF ELECTRIC TENSION AS THE CAUSE OF YELLOW FEVER.

Yellow fever is a pestilence which makes periodical visitations in different parts of the world, and decimates the inhabitants by its virulence as frequently as it returns. Its inroads are chiefly confined to countries in the torrid regions of the earth with an elevated temperature, as in the West Indies, the United States of America, the towns on the west coast of Africa, and Spain. But to this day no adequate cause has been assigned for its appearance. The same darkness hangs over the minds of medical men regarding the cause of this disease as regarding that of the other pestilential diseases which occasionally make fearful ravages in the various families of the human race. Darkness and difference of opinion will continue to prevail till the time come when the true cause will be made evident to the minds of men. If this consummation were attained, there would then be an end to all controversy, as all grounds of contention would be removed.

That yellow fever, like most other diseases, may arise from alteration of electric tension is highly probable, when we take into account the atmospheric vicissitudes, the geological peculiarities, and the facilities for evaporation which exist in those situations in which this disease prevails.

In an attack of this complaint, there are more sudden and violent manifestations for evil than in an attack of any other of the pestilential diseases. This may be concluded by paying a little attention to the symptoms, and accounting for them on the principles here advocated. Of four grades or degrees of severity, Dr. Copland describes the symptoms of the second in the following manner:—"The more severe and more frequent form appears more suddenly, and the symptoms are much more violent. The attack is ushered in by shivering and rigors. The pain in the orbits and forehead is excruciating; severe pain is also complained of in the loins and calves of the legs; the face is flushed; the eyes are glassy, suffused, and apparently inflamed; the pulse is rapid; the skin burning, hot, and dry; and the tongue is loaded, but moist, with little thirst. A few hours afterwards, uneasiness of stomach, with nausea and vomiting, supervenes, followed by severe pain and tenderness at the epigastrium, with a sense of rawness, heat, or inflammation in the fauces and down the œsophagus; great anxiety, restlessness, and watching, with a desire of sleep. The bowels are constipated; the evacuations scanty and deficient in bile; the urine dark-coloured and small in quantity."*

As in almost all diseases, there are first severe rigors—an evidence that the nervous system has received a shock, as if an abstraction of power had taken place. The shock given to the nervous system by the abstracting influence is not borne

* Copland s Med. Dict.

by the cerebro-spinal portion alone, but the ganglial portion suffers also; and it is upon this portion of the nervous system that the blood depends for its vitality.

This is indicated by the distribution of the nerves, as they are found to terminate on the internal membrane of the blood-vessels. Now, when even a portion of the power is abstracted from these ganglionic nerves, the changes in the blood and the excretions from it will be imperfectly made, and besides, being shorn of a large portion of its vitality, it will be unfit for circulating through the capillary system. It is in this way that the blood is deteriorated, as the changes are not produced; the vital operations being in great measure suspended, the blood becomes poisoned by poison from within. One effect of the abstraction of its power will be an inability of the nervous system to effect those operations of digestion and assimilation which it is its office to perform. Hence will result the impurity of the blood, because those bodies remain in this fluid which would have been thrown off by a continuation of healthy action. The blood contaminated by the retention of the bodies which ought to have been thrown off by the kidneys and other excretory organs, and, circulating through the capillaries, will cause irritation in the delicate coats of these vessels. The natural condition of the corpuscles of the blood must be very much changed by the presence of these usually excreted bodies, and rendered very unfit to pass through these attenuated tubes. In place of the blood gliding easily through the vessels at its ordinary speed, it will require additional pressure from the heart and arterial walls. As a consequence, there will be pain in different parts of the body, because of the dilatation of the coats of these capillaries; and the pain will be severe in proportion to the tenuity of the vessels carrying the blood. The capillaries of the membranes of the brain must be of this attenuated character ; and their coats may easily yield, and be congested ; and this structure, being enclosed in a bony, unyielding case, as is the skull, may cause the severe pain which is found in the head in yellow fever.

As a consequence of the vitiation of the circulating fluid, the alteration of its composition, and the want of adaptation to the attenuated vessels, the circulation will be hurried, and the heart will be called to act more powerfully to force the changed and ill-adapted blood through the delicate capillary system. The suffusion of the eyes, and hæmorrhage from them, and from the nose, mouth, ears, and other mucous outlets, may all arise from the injecting effect of the vitiated fluid which is circulating through the extremely delicate capillary structure of their membranes.

A manifestation of these evils in an intensified form is produced in this disease in the mucous membrane of the digestive canal, as shown by the severe pain in the epigastrium. When the capillary congestion is more and more aggravated, the vessels eventually burst, and allow the extravasation of their contents, thereby giving rise to the presence of blood in the stomach, producing black vomit. The dilatation and congestion of the capillaries of the mucous membrane of the bowels will arrest the ordinary secretions from its surface, and deprive the contents of the bowels of their lubricating effects, which, in the normal condition of the system, assists in preserving the patency of the intestinal canal. The pains in the loins and extremities may have their origin from the same cause.

There are found in post-mortem examinations of those who have died of this disease appearances of the viscera, and other textures of the body, which go far to verify the views here advanced. The textures are found softened and broken up. The appearances are well described in the following passage: *—" *In the most malignant* and rapidly fatal cases, a lemon tint of the surface, with livid or dark blotches, is generally observed. The ears, fingers, penis, scrotum, and, in some, the hands and arms. soon become of a dark or brownish hue. The *muscles* are softer and flabbier than natural, of a dirty or dusky hue, and are easily broken down by pressure. The substance of the *heart* is similarly changed. Softening or greater friability of the tissues soon after death is generally remarked, and is extended to all the organs and viscera. The *body* seldom appears to suffer any diminution of its bulk, as in other fevers; and when the fatal issue has been rapid, and the quantity of black matter vomited has not been very great, the several viscera are more or less congested, and the body seems even more tumid than natural, as well as discoloured, presenting a marked putrid or malignant aspect, indicating a remarkably rapid loss of the vital cohesion of the several textures. In such cases as present any diminution of the bulk of the body, the muscles are paler, softer, and more flabby than usual; the viscera

* Copland's Med. Dict.

paler and softer, and even somewhat shrunk; and the blood-vessels contain very little blood. In these cases, a very large portion of the blood has been exuded from the digestive mucous surface, and been thrown off during life in the form of black vomit, or of passive hæmorrhages, from the alimentary and other canals.

"The *liver* is changed chiefly as regards its cohesion and degree of congestion. It is almost always softer and more friable than natural; in some cases congested, in others pale, according to the quantity of blood evacuated during life, in the form of black vomit. Light olive-coloured patches are sometimes observed in it. The *gall-bladder* most frequently is shrunk, and contains little or no bile. The *spleen* and even the *pancreas* are somewhat softened; and the former frequently congested. The *œsophagus* and *stomach* present discoloured streaks and patches, of a dirty purple, dark, or livid colour, in their mucous surface, and the latter viscus often contains more or less of a similar fluid to that constituting the black vomit. In cases where the quantity of this fluid thrown off has been great, the stomach, intestines, and other viscera are paler but also much softer than natural. The *small* and large *intestines* are often contracted in parts, and occasionally introsuscepted. In other respects they offer the same appearances as noticed in the stomach, but in a less degree. They often contain small quantities of fluid similar to that voided before death, but this presents neither a bilious nor a fæcal character. The *epithelium* of the digestive mucous surface seems to be more or less detached in the several portions of the canal; and the mucous membrane is softened and readily separated from the adjoining tissue. The *follicular glands* are not prominently affected, further than being somewhat enlarged in some instances. In those cases which present congestion of the chief organs, as of the brain, lungs, auricles of the heart, liver, and kidneys, slight serous effusion, sometimes sero-sanguineous, is occasionally also found in the *chief cavities*, particularly the pericardium and arachnoid, and but rarely in the peritoneal and pleural cavities: The urinary bladder is always empty and contracted."

The above-described appearances are just what might be expected from the operation of a vitiated condition of the blood, which, forcing its way through the capillary tubes, and being unable to pass through them, causes the vessels to give way, and present the broken-up condition of the various organs of the body. The lividity, and the dark blotches on the pendulous parts of the body (where the capillaries are least supported), are caused by their bursting and depositing the black blood under the skin. The soft and flabby state of the muscles arises from the broken-up condition of the small tubes, which compose so much of their texture. The friability, the loss of the vital cohesion of the tissues, all arise from the same cause. The empty condition of the large blood-vessels may arise from their continued and powerful action forcing the vitiated blood into the capillaries, and causing the exudation of this fluid when the capillaries burst. In no other manner can it be more satisfactorily explained, that the viscera and other textures of the body should be found soft and friable, pale and livid, presenting many hues, according to the number and nature of the various textures of the human body. They may arise from the disorganisation and bursting of the capillaries, and the deposition of their vitiated contents.

There is exhibited, in the phenomena constituting this disease, a course of events which can be appreciated on the principles here advocated. We have the abstraction of the neuro-electric power; then, as a matter of necessity, the inability of the nervous system to carry on the vital operations. The assimilating organs become paralysed, the excreting organs cease their operation, and the impurities which it is the office of these organs to abstract remain in the blood; and thus this fluid is vitiated. The heart is exerted to increased action by this adulterated fluid, which it sends along with augmented force, but which seems to be arrested in its progress by the capillaries, through which, either from spasm of their walls, or from the altered size of the corpuscles of the blood, it cannot pass; and the heart continuing to inject these small vessels, they, by a physical necessity, must burst, and pour their contents into the parenchyma of an organ, or on the surface of a mucous membrane, or into a serous cavity. It is remarked, that, though found in other serous cavities, serous effusion is very rarely found in the cavity of the peritoneum. This may depend on the immense discharge from the mucous membrane on the other surface of the bowels, as, when such a quantity of the sanguineous fluid is thrown out on the mucous surface, there will be but little to spare for the peritoneal cavity.

The reviewer of a work on yellow fever, by

Dr. Townsend, of New York, has the following paragraph:—"Now, if by *affection of the nervous system*, or *nervous disorder*, our author means general derangement of all the properties of the organic tissues, and disorder of every function which depends on the sound state of these tissues, assuredly he is not far from the truth, or, at least, he announces a fact which, to a certain extent, takes place in every case of yellow fever. But that yellow fever consists in a disease of the brain, of the spinal chord, of the nerves of the lungs, or of the nerves of the stomach and intestinal canal, is a conclusion which, we think, few sound pathologists would draw, and with which few sound practitioners would be satisfied. That the properties of the stomach, or gastric tissues, are much altered is undeniable; that the brain differs much from its sound condition, is equally undeniable; but it appears more consonant with correct views of modern action, to think that these morbid states of the brain and stomach consist in the change which takes place in their capillary circulation, and perhaps in their organic properties in consequence, than in any unsound state of the nerves of the stomach or of any other part. The state of the lungs is evidently dependent on the impaired power of the muscles of respiration, and on the consequent difficulty which the blood encounters in passing through the small branches of the pulmonary artery and pulmonary veins."*

If Dr. Townsend, in place of stating that there is disorder of the nervous system in yellow fever, had maintained that there is a loss of power to the system,

* Ed. Med. Journal for 1824.

and no perceptible organic change, then the phenomena described by the reviewer, as characteristic of this disease, might be accounted for with tolerable ease. The vitiated condition of the circulation, as has been already stated,—arises from the diminished power of the nerves, acting on the assimilating organs, producing vitiation of the blood, causing it to pass with difficulty through the capillaries, and ultimately producing rupture of their coats. This accounts for the altered state of the gastric tissues. The impaired power of the muscles of respiration may arise from the weakened condition of the nerves of respiration; while the altered condition of the blood will contribute to the difficulty with which this fluid passes through the small branches of the pulmonary artery and veins. All those morbid phenomena exhibited in this disease can be more satisfactorily explained on the principles here maintained, than on the mere hypothetical notions which have hitherto occupied the minds of medical men.

The more closely the symptoms and morbid manifestations of this disease are considered, the more evident does it appear that a powerfully operating agency is at work, to strike down so effectually the energies of the human frame. The stroke is not borne by any particular organ, to waste the system by sympathetic fever, and the slow and intermitting cutaneous excretions of intermittent fever, but the injury is sustained by the body as a whole, as every organ and every texture is more or less involved in the derangement and ultimate disorganisation.

Mr. Ritchie, in his article on the Medical Topography of the Western Coast of Africa, in the *Monthly Journal of Medical Science*, for May 1852, says:—* "Europeans almost universally, and even natives, are subject to be attacked by it (common endemial fever); but neither of them in a greater degree than in many other localities along this coast. Here, as elsewhere, it appears as the result of a reduced or deranged state of the vital powers, produced by any of the numerous causes which effect these. That the Europeans are more disposed to disease will not appear unaccountable when we take into consideration the effects of a relaxing climate, and a mode of life opposed to the enjoyment of perfect health, contrary to their former habits. These act by *reducing the nervous energy*, and consequently diminishing and disturbing the assimilating and secreting functions."

Without any intention of supporting a hypothesis, Mr. Ritchie, in his paper, recognises the reduced and deranged condition of the vital powers, and also the diminution of the nervous powers. He can appreciate the debilitating effects of dissipation. The diminution and disturbance of the assimilating and secreting functions are both the result of diminished electric power.

With very few exceptions, this complaint is confined to those countries which are situated within the torrid zone. It is here where atmospheric vicissitudes are most frequent and complete, where the tornado and whirlwind make periodical devastations. Like the pestilence already considered, yellow fever prevails most generally in situations where there exist the greatest facilities for the development of

* Monthly Journal of Med. Science, May, 1852.

rain and moisture. This is verified by the statements of many observers. In the following paragraphs, Dr. Copland mentions, that the condition which favours the production of yellow fever is humidity. This is represented as a very necessary agency in the production of this disease, but yet only in so far as it favours the development of the infectious seminium:*—"*Of the extensive influences or agents* which tend not merely to predispose the system to the action of the specific cause of hæmogastric pestilence, but also to aid in developing the effects of this cause, *warm, humid, and stagnant states of the atmosphere* are the most remarkable. This pestilence has generally prevailed during high ranges of temperature, and at that season and in those localities in which considerable humidity was associated with warmth; and these with a still or calm state of the air, or with crowded habitations and imperfect ventilation. Such has more particularly been the case when this distemper has become epidemic in countries without the tropics. Within the tropics, all sheltered *situations near the level of the sea, or near the sea-coast*, present at all seasons the conditions, in respect of warmth or humidity, requisite to the epidemic prevalence of the malady. Still, though these conditions are required for the development and dissemination of the infection, they are not either individually or conjointly capable of producing the distemper without the operation of the specific exciting cause. They are merely the atmospheric condition required to give the infectious germ activity.

"The *seasons* which are characterised by a high

* Cop. Med. Dict. vol. iii. p. 151.

range of temperature and much humidity, as summer and autumn, are those in which this pestilence has become prevalent in temperate climates, when the infection has been imported or conveyed thither. A low range of temperature *and dryness of the air*, although attended by much heat, have been found, on the other hand, to check the propagation of the distemper, and even to prevent its development. When the infectious seminium has been introduced in a crowded locality during degrees of atmospheric warmth and humidity favourable to the evolution and propagation of its effects, and when the consequent epidemic has become very general, the distemper often continues to rage, although the temperature of the season has fallen much below that observed during its outbreak, or even below that which is believed requisite for its development. This has been remarked in respect of epidemic visitations of the pestilence both in Spain and in the United States. That unusually high ranges of temperature have no influence alone in producing the malady, may be inferred from the facts observed in connexion with the prevalence of it both in hot and in temperate climates; for the period of its appearance in the one, and the seasons of its occurrence in the other, have not been always, or even generally, characterised by unusual warmth. Indeed, a careful perusal of facts connected with the outbreak of the distemper in Africa, the West Indies, in Spain, and in America, fully convinces me that excessive warmth is not concerned in its production, more than a somewhat lower grade; a high degree of heat, as I have just stated, being only one of the conditions requisite to its prevalence;

but then the presence of the efficient agent—the infectious seminium—is indispensable: this is the seed; warmth *and humidity* are merely the condition of the soil requisite to its germination, and although the former may lie dormant for a time till the latter give it activity, still it is not less the efficient specific, and the undoubted cause of the pestilence."

The warmth, the humidity, the vitiation of confined respired air, and the stagnant condition of the atmosphere, are all comprehensible ideas; and it can be believed that they might injuriously affect the animal body, as they all depress the animal powers, and are all cognisable by our senses; but what the infectious germ is, no one can tell: no one has seen or felt this agent, and equally unsuccessful has been the search after malaria. It is not to be wondered at, that many are dissatisfied with the faith they have hitherto placed in these supposed causes of disease. A high temperature is not indispensable to the production of this supposed agency, which may be active in very moderate ranges of atmospheric warmth. Dryness, at all temperatures, is unfavourable to the activity of this "infectious seminium," which, indeed, cannot exist in a perfectly dry state of the air. Although the existence of epidemic disease, and rainy weather prevailing together, is often admitted, yet no definite connexion is traced between them, to establish their relation as cause and effect. There is entertained a suspicion that moisture, in some way or other, gives virulence to the poison; and it is affirmed that, but for the moisture, the poison would be innoxious in many cases and situations. It is not stated, however, in what manner the poison and the moisture combine to produce such a mischievous result. It has seldom been entertained as a question, what is the influence of the moisture *per se*, or how does it act on the poison, to produce the evils which attract the attention of observers in the grave-filling regions of the torrid zone? The vapour is considered to be indispensable to give activity to the unknown poison; in whatever locality, in whatever region of the earth, the vapour must be present. That is another element supposed to be essential to the development of this poison; and the greater the amount of heat, and the greater the amount of moisture, the greater is the virulence of the poison, and the more aggravated is the form of disease produced. This is exemplified in a striking manner on the West Coast of Africa, at Sierra Leone. There are here the greatest facilities for evaporation. There is the heat of the torrid zone, and there are the copious rains peculiar to that region. The operation of this heat on the earth, wet to saturation, must alter to an immense degree the electric tension of any portion of the earth thus acted on. Whilst the sun shines during the day, there will be an electro-positive condition kept up in spite of the drawing off of electricity by evaporation, but so soon as his rays are withdrawn, the heat left in the earth will continue to raise the vapour, and ere his rays return in the morning, the electricity will be so much withdrawn as to leave the situation so operated upon in a highly negative state. This is the alteration of electric tension which acts so injuriously in hot climates, and pre-eminently so in such a place as Sierra Leone. Dr. Winterbottom states that, "during the rainy season at Sierra Leone, a few days of bright sunshine invariably improved the state of the sick." Mr. Coventry, an American writer, states, that "We know that heat alone will not produce yellow fever; it must be combined with moisture." Mr. Coventry does not state this as his own opinion, but as a well-known fact, the result of many observations. During the day, although the evaporation is going on more copiously than at night, yet the heat of the sun keeps up a larger supply of electricity than is carried up by the vapour, and preserves a more positively electric condition. This more positively electric condition during the day accounts for the greater salubrity of pestiferous regions during the day than at night. In support of the position that the wetness of the soil and consequent evaporation are the causes of the insalubrity of Freetown, at Sierra Leone, it may be observed that Mr. Ritchie states, "that the superior salubrity of the barracks at a height of some 200 feet above the town, and in greater degree of the inhabitants higher up on the mountain, gives countenance to the supposition, that it is only in the lower strata of the atmosphere that the germs of this disease are to be found." The reason why the barracks are more salubrious is, that the position in which they are placed gives more facilities for the precipitation of the rains as they fall, thereby securing their superior dryness, and placing them, in some measure, in a state of insulation. Since the time at which Mr. Ritchie wrote the above, Sierra Leone is very much improved in respect of salubrity. Dr. Livingstone, in a letter to Sir R. Murchison, after setting out again on his African researches, informs us that, "It is wonderfully free from mosquitoes, the plague of hot climates, even though the atmosphere has the hot, steamy feel which prevails where the insect abounds. It is to be hoped that they have suffered from the ravages of the fever, for which this place has become famed, and mean to remain away. Some of the older inhabitants (and among the rest Mr. Oldfield, the traveller, whom I was happy to meet here hale and hearty) inform me, that Sierra Leone has been much more healthy during the last ten years than it was previously. This I conclude to be the result of the drainage of Kroo Town, which has been accomplished by the present Governor, Colonel Hill. The streets, which were formerly full of holes, where the water lay stagnant, filthy, and green, till the sun licked it up, diffusing, in the meanwhile, the fatal seeds of fever and death, have all been raised in the middle, and runs made for the surface water to flow into the sea. This is a great improvement, and a corresponding amelioration of public health has been the result."

It is also stated by Mr. Ritchie, that the higher up the mountain the greater the immunity from disease. This is precisely what might be expected from the greater insulation. That the superior height and consequent dryness were the cause of the superior salubrity of the barracks, and not the distance from "the germs of this disease," which are to be found "only in the lower strata of the atmosphere," may be concluded from another statement by Mr. Ritchie about the condition of "Bathurst, the first British settlement on this coast. It is situated at the mouth of the river Gambia, on the hot dry sands of the island of

St. Mary. The population consists of between thirty and forty white men and 2,000 negroes: the former is constituted by the functionaries of the colonial government, the missionaries, and individuals engaged in commercial pursuits, for which this appears "an advantageous position, as the river is navigable for 600 miles into the interior."

"In regard to its collateral conditions, no situation could at first sight appear more prejudicial to health than this—a low island, surrounded by a broad marshy beach and almost stagnant waters. This view, however, is shown by experience to be incorrect. In no other locality along the coast is endemic disease found less prevalent or fatal. The rainy season commences in June, and terminates towards the end of September. During all this time rain is more or less frequent. This period of the year is the most pregnant with disease. Fevers are frequent among the white population, and not uncommon among the negroes."

Here is a town built upon a hot, sandy island, surrounded with marshes, and reckoned in the very focus of malaria, yet it is found to be healthy, compared with the situations around. The healthfulness continues till the rainy season sets in, and then fevers prevail; but they are less prevalent, and less fatal, than in the situations in low levels, on the continent at the coast.

On our principles, the cause of the favourable peculiarity in this island is the dry nature of the soil, which is described as consisting of hot sand. In a situation of this character, so long as the sand continues to be hot and dry, people situated upon it will not only be insulated, but will enjoy the advantage of a highly positive condition; and this will continue till a conducting medium is presented to withdraw the electricity which abounds in the sand; and what more fit for this than that universally diffused body—water? The rains, which periodically fall, will, by their evaporation, abstract the electricity, and cause the island to be in a negative, in place of a positive, condition. It is after the rains have fallen, and during the evaporating process, that the diseases begin to prevail; as now the island will be converted into a more electro-negative condition, and thus abstract vital electricity from the animals that are always positive with relation to the earth on which they stand.

The lowness of this island, and its being at the same time comparatively healthful, present a difficulty to the advocates of the doctrine of miasm. Although, as Mr. Ritchie remarks, it is only in the lower strata of the atmosphere that the germs of disease are to be found, yet here is an island, in the very position in the lower strata, and "surrounded by a broad marshy beach and almost stagnant waters," but which, notwithstanding this unfavourable position, is comparatively salubrious. There is evidently absent the powerful agent for evil which operates so mischievously on the same level, and within a short distance, on a neighbouring shore.

Mr. Ritchie states, in another part of his paper, that the inhabitants residing in barren situations are not liable to be attacked with fever. There are implied in desert places the same heat and sandiness that exist in the island of St. Mary. In the desert there is the heat without the moisture, and it is because there is no moisture that the desert is free from pestilential disease.

Heat, *i.e.* electricity, is the most important element in nature. Without electricity neither animal nor vegetable life could be maintained for an instant. Robbed of its latent electricity—its principle of cohesion—the world would instantly crumble into powder. Since electricity is so universally operative in every department of nature, it is improbable that any amount of that free electricity, which is so continually communicated by the sun and can be comfortably borne by our feelings, can be hurtful or injurious to animal life. This is demonstrated by life in the desert. Here, though there is heat, there is very little moisture, and there is the absence of epidemic diseases.

Dr. Livingstone mentions, that during the blowing of the Harmattan winds from the desert, when a non-conducting body, such as a feather, was held in the current, electricity sparkled most vividly, when friction was made on it with the hands. This is a satisfactory demonstration that the desert is positively electrified in the truest sense of the term; and that such a condition of the air is healthful was found by Dr. Livingstone, as neither he nor any of his party was troubled with sickness, so long as they were in the desert. So soon, however, as they came to the vicinity of lakes or rivers, where there was evaporation, it was then that their fevers began. So true it is that a dry situation, such as a desert, is found to be free from fever. Though pestilence rage on its margin, yet do the inhabitants of the barren wilderness remain free from its attacks. So long as the desert is dry, it is in a positive condition, and it is on this that its salubrity depends. By adding to the dry sand, however, a certain measure of water, sufficient to cause copious evaporation, there will be produced alteration of electric tension. From a highly positive state it will be changed into a highly negative one. In these places which have all the characteristics of the desert, such as the absence of every vestige of vegitation, but the subsoil saturated with water, there must be a persisting negative condition which will injuriously affect those exposed to its influence. This is found to be the case in some parts of Holland, as has been observed in a former part of this work. In dried water-courses there is the same insalubrity, arising also from a saturated subsoil. The following, taken from Dr. Watson, is an example of this:—

"Cividad Rodrigo is situated on a rocky bank of the river Agueda, a remarkably clear stream; but the approach to it on the side of Portugal is through a bare, open, hollow country, that has been likened to the dried-up bottom of an extensive lake; and upon more than one occasion, when this low land, after having been flooded in the rainy season, had become as dry as a brick-ground, with the vegetation utterly burnt up, there arose to our troops fevers which, for malignity of type, could only be matched by those before-mentioned on the Guadiana."

There could not arise in the mind, in contemplating the cause of the insalubrity of this situation, any suspicion that decomposition of animal or vegetable matter had to do with the unwholesomeness. Although the rain was dried off the surface, yet there was a large reservoir of water under the surface, and this being heated by the hot ground, a large evaporation would be produced. The above-mentioned hollow country, which was so unfavourable to the health of the British troops, may be supposed to be in the same circumstances as the dried-up bed of the river Guadiana, referred to before. After it had been flooded over, and formed into an extensive lake, the ground, stiff and retentive, will be so saturated with water, that though the surface be dried up, and the short-rooted vegetation found on it burnt up by a long-continued drought, yet water may be found at a small depth under the surface, and, by the same means, give rise to the same evils which were so fatal at Walcheren. In another passage, Dr. Watson makes mention of the following facts:—"It is a singular but well-ascertained fact, that the miasmata lose their noxious properties *by passing over even a small surface of water*. Probably they are absorbed by it; and this is another proof of their tendency downwards. Many instances have been already referred to where some of the crew of a ship have landed on a malarious coast, and have all been attacked by the fever; while the rest of the sailors, who remained on board, continued all healthy and well, though the ship was close to the shore. You could not have a better or more striking example of this than what took place at Walcheren. 'Not only the crews of the ships in the road of Flushing were entirely free from the endemic, but also the guard-ships which were stationed in the narrow channel between this island (Walcheren) and Beveland. The width of this channel is about 6,000 feet, yet, though some of the ships lay much nearer to one shore than to the other, there was no instance of any of the men or officers being taken ill with the same disorder as that with which the troops on shore were affected.' This Sir Gilbert Blane has told us; and it is curious that Sir John Pringle made the very same remark, in the very same place, in 1747. He is speaking of the diseases of the campaign in Dutch Brabant; especially in reference to four battalions which had remained for some time in Zealand: and he says, 'But Commodore Mitchell's squadron, which lay all this time at anchor in the channel between South Beveland and the island of Walcheren, in both which places the distemper raged, was neither affected with the fever nor the flux, but amidst all that sickness enjoyed perfect health; a proof that the moist and putrid air of the marshes was dissipated, or corrected, before it could reach them.'"

It is the disadvantage of those who embrace mere theory, unsupported by rational principles, to meet with difficulties in the course of their observations which they cannot easily explain. This is pre-eminently the case with those who adopt the view that miasm is the remote agent which causes epidemic disease. That this is the case in the observations in the above quotation is evident. That miasm can lose its noxious properties by passing over a small surface of water, by gravitating into it, is purely hypothetical. It will first be necessary to discover what the agent really is, and whether it is subject to the laws of gravitation, before placing confidence in the supposition that miasm is absorbed by water whilst it passes over its surface. Its supposed ponderous qualities rest on the circumstance that, in the situations where diseases are endemical, it is found, the lower the locality, the more active and virulent is the deleterious agency. Even in those places where miasm is supposed to exist in its most concentrated form, where its ponderous and gravitating properties will be most likely to be manifested, even here it escapes the keenest research. In place of stating that the fact is well known, that miasm loses its noxious properties by passing over a small surface of water, it would be more correct—and is as well known—to state that disease often exists to a great extent on one side of a river, and does not pass over to the other, and that diseases often rage on one side of a lake, whilst the people on the opposite shore are quite healthy. The wind must frequently blows from the sickly to the healthy side, and yet no effect of a mischievous nature has been remarked in circumstances of this kind. This much is known for a fact, but the cause—whether miasm or some other agency—is still an open question. Now the ships in the road of Flushing were in the same relation to the coast as the healthful bank of a river to its pestiferous neighbour on the opposite side. The ships of the fleet were placed closely to the shore of the unwholesome plain, where their fellow-men in the service were being decimated by intermittent and remittent fever. If malaria had really been the cause of the diseases, and if it can be known to possess such a property as ponderousness, the wind, on some occasion, must have blown from the shore with such force as to carry the malaria over to the ships, notwithstanding its gravitating peculiarity—its tendency to sink into the water. That this did not take place is well known. We have the testimony of three separate naval authorities, who had been placed in the same situation on three separate occasions, and they all bear the same kind of evidence. One states, as above, that "there was no instance of any of the men or officers being taken ill with the same disorder as that with which the troops on shore were affected." On the principles here advocated, the safety of the seamen depended on the good non-conducting properties of the timber of the ship. Whilst the poor soldiers on the shore were exposed to the continued fluctuation of electric tension,—positive tension during the day and negative tension during the night,—produced by the evaporating surface on which they were placed, the seamen were not so exposed, being on a dry, non-evaporating surface on board timbers hips. The wood being a non-conducting body, the seamen were not operated upon by the abstracting power which reduced the nervous forces of the soldiers.

Dr. Watson remarks that "it has repeatedly been observed among the crews of ships, when off a malarious coast, that the sailors could go on shore in the day to cut wood, or for other purposes, with impunity; while the men who remained on shore, during the night, guarding the water-casks, were many or all of them seized by the fever. Take one instance as a sample of many. It is recorded by Dr. Lind. In 1766, the Phœnix ship of war was returning from the coast of Guinea. The officers and ship's company were perfectly healthy till they touched at the island of St. Thomas. Here nearly all of them went on shore. Sixteen of the number remained for several *nights* on the island. Every one of these contracted the disorder, and thirteen of the sixteen died. The rest of the crew, consisting of 280 men, went in parties of twenty and thirty on shore every day, and rambled about the island hunting, shooting, and so on; but they returned to the ships at night; and not one of those who so returned suffered the slightest indisposition. Exactly similar events occurred the following year, with the same ship, at the same place, where 'she lost eight men out of ten, who had imprudently remained *all night on shore;*' while the rest of the ship's company, 'who, after spending the greatest part of the day on shore, always returned to their vessel before night, continued in perfect health.' Many more examples of the same kind are stated or referred to by Dr. Bancroft, in his book *on the Yellow Fever*,—a book which is rich in information respecting the malaria."

These facts are a good illustration of our principles. During the sunshine, the heat, which is absorbed, places the locality thus acted upon in a positive condition, and the seamen, occupied on shore during this time, will not suffer any diminution of nervous power; they may rather become invigorated: whereas the seamen left to guard the water-casks during the night lost the invigorating influence of the sun, and required to contribute heat to the earth, to assist in raising the vapour; hence the abstraction of nervous power, and the diseases consequent thereon.

The ship's company of the Phœnix were perfectly healthy so long as they remained in the ship, just because the timber of which the ship was made is an excellent non-conducting body. During every successive night on which the men remained on land, they would suffer an additional abstraction of nervous power. Those who rambled about the island did so when the rays of the sun were beating both on them and on the island, when the island would be in a highly electric condition, and they would receive no harm.

The following statement was made to the writer by an observant seaman. He stated that he had made five voyages to the West Indies, and he always observed that the seamen were not affected with yellow fever as long as they remained in the ship; but when they left the ship, and remained all night on shore, they were almost sure to be affected with fever, and frequently had a rigour before they returned to the ship. When the sun was shining during the day, the seamen could leave the ship with impunity. He himself had frequently done this. The object of the seamen in going ashore at night was to indulge in drunkenness and other forms of dissipation, which would produce a ready predisposition to any species of fever.

In a review of the work of Dr. Macculloch on Malaria, in 1828,* the same testimony is borne regarding the safety of ships near a coast where epidemic disease is raging. It is a "well-known fact, that our ships moored close along the banks of the Scheldt entirely escaped the fever, while our soldiers quartered within half a cable's length of them were all affected with the endemic." Half a cable's length is surely a small space over which the malaria had to pass to reach the seamen in these ships; and if this malaria has any activity, its ponderous property is certainly not so great as to prevent its passage over a distance so small. There is no doubt but that

* Med.-Chir. Review for 1828.

the seamen breathed the same air which was inhaled by the soldiers on shore. There could be no difference in the air surrounding both, either by night or by day; yet how different their condition in point of health! It is far from flattering to our understanding when we invent an agent and attribute to it active powers for evil, and also weight,—a property common to almost all bodies,—without knowing what the body really is.

The principles here advanced may be applied to ascertain whether the difference between the condition of the seamen and the soldiers may be accounted for. The soldier at Walcheren was laid in his blanket upon what appeared to be dry sand, but with water a few inches under the surface. The seaman, as a matter of course, was placed on the timber of the ship. The radiation of heat from the soldier would be actively carried on by the good conducting power of the water, and the readiness with which it is turned into vapour; there being no end of the capacity of the water for the heat, which is drawn from the soldier, from the time he lies down till he rises, and hence the evils resulting from nervous exhaustion. The seaman is suspended from wooden beams in his hammock and blanket. The blanket is a bad conductor of heat, and thus far the soldier and seaman would be equally protected; but the hammock of the seaman would be of another texture, such as linen, still a much worse conductor of heat than water. The beams to which the hammock was suspended, being of wood, are also bad conductors, and would not withdraw the electricity from the body; so that the seaman would rise in the morning without the nervous exhaustion experienced by the soldier after his sleep on the damp soil. The seaman all day long would, when pacing the timbers of the ship, be on a good non-conducting body; and the soldier, so long as the sun shone, would, whilst pacing the surface on which he lay, be on a warm surface, at the time highly positive, and be perfectly safe. A fact, corroborative of this, is mentioned by Dr. Watson. The reapers in the "Campo Morto," a marsh in Italy, are permitted to sleep on the ground for two hours about noon. They do so at that time without danger; but when the dews of evening have fallen down upon the earth, which serves them for their bed, it is then that the poison puts forth its most deadly power. There are certainly here, to obscure the truth, vegetable life and vegetable death; but when we find at Walcheren, and other like places, the same amount of disease, and neither living nor dead vegetable matter, but what is common to all the situations—water in an active state of evaporation, how probable is it that it is the water all the while that is the offending agent. The desert may be traversed for months under a burning sun, the traveller may sleep uncovered in the open air during the night, without the fear of the pestilence that "walketh in darkness." Dr. Livingstone, so long as he pursued his journey in the desert, experienced no fever. If this same desert were saturated with water and kept so, at the same time yielding active evaporation, there would be the same insalubrity as exists at Walcheren and many like places.

The same testimony is given by every writer on epidemic disease in the torrid zone, viz. that moisture is indispensable to the production of fever. There are certainly situations in different parts of the world, which, apart from moisture or vegetable or animal decomposition, are so insalubrious as to be quite uninhabitable; but the cause of this will be adverted to in another part of this work.

Dr. Belcher, in 1823, made some observations on the Tropical Endemic Fever. The following is a quotation from his paper:—*

"This fever generally appears at a particular period of the year, in a milder or more severe form, varying according to the state of the weather during the season. Solitary cases will be met with at all periods; but the most usual period of its appearance is during what is called the rainy or sickly season. From December to May, the weather is dry, and much more temperate than during the other months; and, consequently, this period of the year is much healthier, being called the dry or healthy season. About May, or perhaps later, the rains commence and fall in torrents, at the same time the heat of the weather is gradually increased, until the thermometer of Fahrenheit rises to 86°, and varies then, till October, from 80° to 93°, and even to 96°, in the shade; it has been known to have reached 103° in the shade, and 140° in the sun, though, I must confess, I never experienced that degree of heat there. The utmost I ever felt was 92° in the shade. The atmosphere during the rainy season is often very dark and cloudy, and the sun does not shine out; so that the quantity of rain which falls remains, and becomes stagnant in the low grounds, from which exhalations of a most deleterious character are often emanated. All who happen to

* Ed. Med. and Surg. Dict., April, 1825.

labour under fever near these noxious exhalations have the disease in a most aggravated form; the weather at the same time becomes excessively hot and close, although not a gleam of sunshine is to be observed; the thunder rolls awfully, accompanied by most brilliant flashes and sheets of lightning; and the rains fall from the clouds in quantities scarcely to be credited by those who have not witnessed them. This kind of weather tends peculiarly to depress the mind, and I think predisposes a great number, particularly those who are alarmed, to attacks.

"All the West India Islands have their healthy and unhealthy seasons, varying according to their surface, whether flat or mountainous, woody or cleared, dry or intersected with marshes. Barbadoes is, generally speaking, one of the most healthy islands. It is moderately above the level of the ocean, clear of wood, has scarcely any swamps, and is generally well cultivated. Parts of Jamaica are exceedingly unhealthy at different seasons, particularly Kingstown, the principal town. It is rendered unhealthy by its proximity to marshes. Here intermittents are very frequent, and the endemic fever now and then assumes a most malignant character. The north side of the island is more healthy; and persons are sent for change of air to Montego Bay, Port Antonio, Falmouth, and many to Barbadoes, which is considered as the Madeira of these islands. The comparative difference of health between the army and navy on the West India station is remarkable, as soldiers are much oftener attacked than sailors, and more cases terminate fatally."

As in other situations where epidemic diseases prevail, there is a healthy and there is a sickly season; so it is as regularly found, that here the dry season is the healthy, and the wet the sickly. This writer represents that all those who lived nearest the source of the evaporation had the disease in the most aggravated form. This is what would be expected on the principles here maintained. The more copious the amount of evaporation, the larger the draft of electric fluid from the earth, the larger the draft of electricity from the animals on the earth, to supply that which is carried up. This loss of nervous power will disable the vital organs for normal action, and will institute diseases produced by impurities in the blood. As a consequence of the evaporation, there is a large quantity of electricity carried up into the clouds, and it is on this account that "the thunder rolls dreadfully, accompanied by most brilliant flashes and sheets of lightning." This lightning is the electricity which would have been left in the earth, if the weather had always been dry. Were this the case, the earth would always be positive, and the animals on it would enjoy a positive condition, and consequently be well.

The last paragraph of the above quotation is another illustration of the truth of our position. Barbadoes is singled out as the most healthy island, because it is in the best condition to be dry; it is cultivated, has scarcely any swamp, and being known to be salubrious, it is considered the Madeira of the West Indies. The observation, that the seamen are more healthy than the soldiers, is a corroboration of what has been already stated on that subject. Dr. Wilson bears testimony to the general dryness and healthiness of the island of Barbadoes, but states that occasionally it is "afflicted with fever in its most malignant and mortal forms." In a tropical climate, in a country which is generally dry and healthy, the people may have left off those precautions which are constantly observed by people living in unwholesome situations; and when an unusually wet season comes and over-saturates the soil, there is set up a most active evaporation, which speedily converts the formerly positive condition of the surface into the opposite negative state, and affects the people injuriously, by abstracting from them some of their nervous power.

Dr. Proudfoot, in a paper in the *Edinburgh Medical and Surgical Journal*, vol. xxviii., on the Endemic Fever of Spain, makes the following statement regarding the increased salubrity of the West Indies by the draining of the swamps, &c.:—"The deaths among our troops in some of the West India Islands, during 1796, seem to have amounted to nearly one-half of the whole number employed. Compared with this mortality, the number of deaths now is incredibly small, being only about one in thirty-five of the sick list. The improvement is partly owing, doubtless, to the very great changes in the medical treatment of disease; but much more is due to the clearing away of brushwood and long grass, and the draining of swamps and marshes, the construction of barracks and hospitals in more healthy situations, and various other improvements for the health and comfort of the soldiers, introduced at the suggestion of the Army Medical Board."

From this observation it appears that the mortality amongst Europeans was very great during the last century in the West India Islands, but since that period they have been much more healthy. There are various reasons assigned for this improvement, but they are all second in importance to the draining of the swamps and marshes. By this means the facilities for evaporation were effectually removed, and the people placed on these islands would always be enjoying a comparatively positive condition of the soil. The means taken to drain the swamps and marshes would also carry off the water which fell during the rains, and thus preserve dry and warm those situations which were formerly drowned in swamp. The brushwood and long grass were merely accidental, and had no mischievous influence. It is always of importance to have the barracks placed in the most healthy situation, as it is in these institutions that soldiers pass the greater part of their time.

It has been observed, that yellow fever sometimes prevails in situations which have little or no swamp, and does not infect those places which are surrounded with swamps. In the critical analysis of Dr. Wilson's Memoirs of the West Indian Fever, in the *Edinburgh Medical and Surgical Journal*, it is stated that,* "In proceeding to the second species of argument, that marshes occur, nay, may abound, where yellow fever is rare, or completely unknown, Dr. Wilson first contrasts the city of Rio Janeiro with that of Vera Cruz,—both under nearly equal parallels of latitude; both built on a low sea-shore ground, skirted by high mountains, though at unequal distances; the religion of the inhabitants the same, and their habits and modes of life very

* Ed. Med. and Surg. Journal for 1828, p. 197.

similar. Yet while Vera Cruz, without a rood of marshy soil, is a hot-bed of West Indian fever in its most violent forms, within Rio Janeiro, though placed near an extensive swamp, and liable to ague, yellow fever was never known.

The instance of the settlement of Demerara is still more appropriate. This narrow tract, low, level, extending along the sea-coast, and intersected with canals and ditches, alternately inundated and covered with stagnating oozy water, abounding with vegetable matter,—where the soil is a swamp, and the ditches are marshes,—might be supposed to be the prolific source of yellow fever. The general suffrage of medical opinion, indeed, influenced by theoretical considerations, pronounces this territory unhealthy; and the inhabitants are doubtless subject to agues and remittents. These diseases, however, are not severe; and Dr. Wilson states, from official documents, that during six successive years, from 1805 to 1812, the proportion of deaths to the number of the sick was much below that of any other British settlement in the West; as low, indeed, as in England during the same period. He further informs us, that the inhabitants are healthy and long-lived, on an average of years, in a degree little inferior to those of Great Britain. What is most to the point, however, is that, as far as he has been able to ascertain from published and oral statements, the concentrated West Indian fever is exceedingly rare in Demerara.

"The argument is closed by the example of Honduras. The physical situation and character of this colonial tenure are well known. Close on the sea, and occupying part of a large bog, on which foundations for the buildings have been gradually formed principally from the ballast of ships which have gone thither to load mahogany and dye-woods, it is represented by Dr. Wilson, who was there in 1825, to be during the rainy season a perfect lake, where teal and snipe are shot from the windows, and where the mosquitoes, sand-flies, and bull-frogs contend incessantly to prevent sleep during the night, yet so parched during the dry weather, that the inhabitants have difficulty in procuring water before its termination. With Porto Bello to the east, nevertheless, and Vera Cruz to the west, Honduras is not unhealthy; and though the inhabitants have much ague, and some remittent fever, yellow fever is scarcely known among them."

The reason of the greater malignity of the disease at Vera Cruz than at Rio Janeiro is that the former may have no part of the surrounding locality sufficiently depending to form swamps, and the rain which falls during the rainy season, after thoroughly saturating the soil, runs off, whilst in the other swampy situations the water does not run off, but fills the swamp more completely. The swamp, in this condition, assimilates a lake, and yields comparatively little evaporation, disturbing but to a small extent the electric tension; but when the swamp becomes nearly dried, then the evaporation is very much increased,—and this constitutes the sickly season. At Vera Cruz, during the dry season, the soil will be dry all around, and there will be no evaporation in its vicinity so long as this dry condition continues, and no yellow fever or other form of endemic disease; but soon after the rains fall, the great heat of the sun on the wet soil will cause a very rapid evaporating process, which will disturb to a great extent the electric relations. A highly negative condition of the soil around Vera Cruz will be produced, and this will act most powerfully in abstracting the electric or nervous power, and hence the sudden and severe form of the fevers.

Demerara, Honduras, and Rio Janeiro, on the contrary, are pervaded with swamps, and although there is intense heat, and a much larger quantity of water exposed to evaporation, the process is not so active, but is much more constant and persisting, and in consequence of this, the localities are kept in a more constant negative condition, but much less negative than that suddenly produced at Vera Cruz. This state of the locality will act less powerfully on the animal system, producing a less formidable type of disease.

As an example of the injurious action of dampness and consequent evaporation, Dr. Livingstone states that "the village of Kilimane stands on a great mud-bank, and is surrounded by extensive swamps and rice-grounds. The banks of the rivers are lined with mangrove bushes, the roots of which, and the slimy banks on which they grow, are alternately exposed to the tide and sun. The houses are well built of brick and lime, the latter from Mozambique. If one digs down two or three feet in any part of the side of the village, he comes to water. Hence the walls built on this mud-bank gradually subside; pieces are sometimes sawn off the doors below, because the walls, in which they are fixed, have descended into the ground, so as to leave the floors higher than the bottom of the doors. It is almost needless to say that Kilimane is very unhealthy.

A man of plethoric temperament is sure to get fever, and, concerning a stout person, one may hear the remark, 'Ah! he will not live long; he is sure to die.' A Hamburg vessel was lost near the place, before we came down. The men were more regular in their habits than English seamen, so I had an opportunity of observing the fever acting like a slow poison. They felt out of sorts only, but became bloodless and emaciated; they became weaker and weaker, till they sank more like oxen bitten by tsetse than any disease I ever saw. The captain, a strong, robust young man, remained in perfect health for about three months, but was at last knocked down, and made as helpless as a child."

There are here, besides the mud-bank on which the houses were built, the marshes, rice-grounds, and mangrove plants. But when we have in so many cases seen that there are circumstances in which active evaporation was maintained, with its attendant insalubrity, with no other agency but the earth and the water, we can easily dismiss from our consideration everything connected with decaying animal and vegetable matter, or any other imaginary agency, and confine our attention to the changes in those elements which we see before us, and which are manifest to our understanding. We do not admit that the vegetation, dead or living, or the dead or living animal matter, could in any way affect the health of the German sailors who were cast away on the above-mentioned village. The great dampness, and consequent evaporation, from this place would cause the soil to be constantly in a negative state, and there would be a continued draft of electric fluid from their bodies. At the period at which the draft has been sufficiently long continued, the nervous energy will become unfit to continue the vital operations with the necessary vigour, and hence the gradual and fatal sinking which was displayed in the persons of these poor sailors. In consequence of a more robust and vigorous frame, the captain was able to bear up much longer against the mischievously abstracting powers which were operating on him, but he, too, sunk in the mud that had already swallowed up his unlucky companions in misfortune.

There are several other parts of Dr. Livingstone's book, in which he attributes the fever which seized himself and party to the excess of moisture in the places where they were situated. At page 167, he remarks that "the rains had been copious, but now great numbers of pools were drying up. Lotus plants abounded in them, and a low, sweet-scented plant covered their banks. Breezes came occasionally to us from these drying-up pools, but the pleasant odour they carried caused sneezing in both myself and people; and, on the 10th March (when in lat. 18° 16′ 11″ S., long. 24° 21′ E.), we were brought to a stand by four of the party being seized with fever. I had seen this disease before, but did not at once recognise it as the African fever. I imagined it was only a bilious attack, arising from full feeding on flesh; for the large game having been very plentiful, we always had a good supply; but instead of the first sufferers recovering soon, every man of our party was in a few days laid low, except a Bakwain lad and myself."

It was when the rains had just fallen that Dr. Livingstone and his party came to this situation, as the surface was just drying up. It is at this time that the greatest change takes place in the electric state of that portion of the earth from which the water is being evaporated. So insalubrious was this place at this stage of their progress that, with the exception of Dr. Livingstone and a young man, the whole party were "laid low." The effect was so powerful that the strongest of them only could resist the shock made on them. The young Bakwain and Dr. Livingstone have had more power in their constitutions, and thus were enabled to resist the morbid influence brought to bear on them. They had a larger amount of nervous power than their fellow-travellers, and could bear a larger amount of abstraction.

In another part of his work, he mentions that when they came to the vicinity of a river, fever prevailed, as there was presented the most favourable condition of the soil for evaporation. "Cold east winds prevail at this time, and as they come over the extensive flats inundated by the Chobe, as well as many other districts, where pools of rain-water are now drying up, they may be supposed to be loaded with malaria and watery vapour, and many cases of fever follow. The usual symptoms of stopped secretion are manifested,—shivering and a feeling of coldness, though the skin is quite hot to the touch of another." Before these flats, mentioned in this quotation, were inundated with the water, they would be in a highly positive condition, and would produce no malaria, that is, the fever-producing agency; but as soon as they were inundated with water, their electric condition would be changed. When the water was dried up, the condition would be still further changed, as the electricity necessary to raise the water would be withdrawn from the soil, which would, in its turn, rob the animals, and occasion shivering and feeling of coldness. Dr. Livingstone complains that various places in his course through Africa were unhealthy and unfit for habitation; and only incidentally mentions, that evaporation is always active, and is at least one cause of their being so. At page 220 of his work, the following remarks are found:—"I imagined the slight elevation (Katongo) might be healthy, but was informed that no part of this region is exempt from fever. When the waters begin to retire from this valley, such masses of decayed vegetation and mud are exposed to the torrid sun, that even the natives suffer severely from attacks of fever." The decayed and decaying vegetation would be prejudicial in no other way than by acting like a sponge, retaining the water, and retarding and intensifying the process of evaporation. Even elevation, which is beneficial in other situations, did not avail in this.

At page 418, the doctor states that "occasionally the quantity of moisture in the atmosphere is greatly increased, without any visible cause: this imparts a sensation of considerable cold. The greater humidity in the air, affording a better conducting medium for the radiation of heat from the body, is as dangerous as a sudden fall of the thermometer: it causes considerable disease among the natives, and the season is denominated casueirado, as if by the disease they were slaughtered like sheep. The season of these changes is the most unhealthy for the native population; and this is by no means a climate in which either natives or Europeans can indulge in irregularities with impunity."

The doctor properly considers that humidity in the atmosphere is a good conducting medium for the radiation of heat. It is, in other words, a good conducting medium for abstracting electricity from the body—for withdrawing nervous power. The insalubrity of the humidity in the air is so apparent as to be considered by the simple-minded aborigines of Africa the cause of so much mortality among them, and, because it prevails so generally, they liken the effects of this humidity on the lives of the people, to the slaughtering of sheep. There is an attendant retribution on the heads of the irregular and profligate in all countries and climes; and this is not surprising, when it is considered what outrageously unwholesome fluids are thrown into an injured and often rebellious stomach. In several places of the doctor's book, he states that his course was arrested by fever, and uniformly attributes it to the humidity consequent on the drying up of the waters. At page 463, we are told that "there is partial winter in the Barotse valley, but, beyond the Orange river, we never have cold and damp combined. Indeed a shower of rain seldom or never falls during winter, and hence the healthiness of the Bechuana climate." And, again, at page 482, "On many of the paths which had been flooded, a nasty sort of slime, of decayed vegetable matter, is left behind, and much sickness prevails during the drying up of the water." It is to the dryness of the winter that the healthiness of the Bechuana climate is attributed; and the unhealthiness of other parts *is considered to depend on the drying of the water*. Nothing is said about the effects produced by the falling of the rain, or when the surface is covered with water.

Dr. Livingstone tells us again "that the Makalolo generally have an aversion to the Barotse valley, on account of the fevers which are annually engendered in it as the waters dry up. Kilimane lies on the low bank of the Zambesi, and is very unhealthy. The Jesuits, far-seeing in what is good for them, chose an elevated site, knowing that it is more healthy." And, once more, at page 495, "The Makalolo, who have been nearly all cut off by fevers in the valley of the Zambesi, declare that, in the high ridges which rise in the neighbourhood, they never have a headache.

"The village of Chitlene is situated, like all others in the Barotse valley, on an eminence, over which floods do not rise; but, this last year, the water approached nearer to an entire submergence of the whole valley than has been known in the memory of man. Great numbers of people were now suffering from sickness, *which always prevails when the waters are drying up*."

The natives of central Africa have used their powers of observation, untrammelled by the influence of prejudice. They find that the sickness constantly follows the drying up of the water after the rains. They forsake the valleys, which have been inundated with water, as they know that fevers will follow. They instinctively ascend the heights, as they know that there they never have a headache. The village mentioned above, though elevated in common with the villages in its vicinity, was rendered more sickly than usual, in consequence of the inundation leaving the ground saturated with water, and requiring a large supply of electricity to dry it up. So long as these villages were surrounded by soil in a dry condition, they would be positive, and it is when in this state the people enjoy the best health. When the villages were all but submerged, there must have been a very extensive portion of the ground saturated with the water, which would require an immense quantity of electricity to raise it up into vapour. As a consequence, the soil would be left, during the drying process, in a much less positive condition than it was before. In place of the highly positive, and consequently healthy condition of the soil, which existed in its dry state, when it might even communicate to the nervous forces of the animals in contact with it, there is produced a condition which abstracts from the animal body, and puts it in a less positive condition, having less nervous power; and if this abstraction be carried sufficiently far, there may be produced enervation of the absorbents and of the capillaries of the vital organs, and hence the diseases which depend on deranged or suspended secretion and assimilation. The Jesuits are a class of men who are wise in their day and generation, and look well to their own safety, as well as their comfort, and as they knew by experience and observation that the elevated position was most healthy, chose that situation, merely because it was most healthy, though they may have been ignorant of the reason why it was so.

Dr. Watson * cites Dr. Ferguson as one who

* Watson's Practice of Physic, vol. i.

considers that the process of drying—that is evaporation—is mischievous independently of any other agency. He states that—"The river Tagus is, at Lisbon, about two miles broad; and it separates a healthy from a very unhealthy region. On the one side is a bare hilly country; the foundation of the soil, and of the beds of the streams, being rock, with free open water-courses, among the hills. This is the healthy side. But the Alentejo land, on the other side, though as dry superficially, being perfectly flat and sandy, is most pestiferous. Moreover, in and near Lisbon there are numerous gardens, where they keep water, during the three months' absolute drought of the summer season, in stone reservoirs. These reservoirs, containing water in the most concentrated state of foulness and putridity, are placed close to the houses and sleeping-rooms; the inhabitants literally live and breathe in their atmosphere. 'Yet no one ever heard or dreamt of fever being generated amongst them from such a source; though the most ignorant is well aware that were he only to cross the river, and sleep on the sandy shores of the Alentejo, where a *particle* of water, at that season, had not been seen for *months*, and where water, being absorbed into the sand as soon as it fell, was *never* known to be *putrid*, he would run the greatest risk of being seized with remittent fever.'

"Now these facts, and facts like these, seem to prove that the malaria and the product of vegetable decomposition are two distinct things. They are often in company with each other, but they have no necessary connexion. Whoever, in a malarious country, waits for the evidence of putrefaction, will wait, says

Dr. Ferguson, too long. For producing malaria, it appears to be requisite that there should be a surface capable of absorbing moisture, and that this surface should be flooded and soaked with water, and then dried: and the higher the temperature, and the quicker the drying process, the more plentiful and the more virulent (more virulent, probably, because more plentiful) is the poison that is evolved."

The reason why the hilly side of the river is more salubrious than the other is quite apparent. Its highness secures its dryness, and consequent comparatively positive condition. The other side of the river, on the contrary, must be highly negative, as the sand allows of the absorption of the rain as soon as it falls, and also of the percolation, in some degree, of the water from the river through the land, as the sandy plain is very little higher than the surface of the water in the river. It will thus yield a constant and plentiful supply of moisture for evaporation in proportion to the height of the temperature. This will produce a condition of the sandy plain nearly like that of Walcheren.

Dr. Ferguson considers that the drying of a surface previously soaked with water is of itself injurious, and the quicker the drying process, the more plentiful and the more virulent the poison; that is, the wetter the soil, the higher the temperature, and the more speedy the evaporation, the further will the electric tension of the soil thus acted on be reduced. This is further illustrated by the following paragraph:—

"There is good reason for believing that in all cases the poisonous emanations proceed from parts of the surface that have been flooded and then dried, rather than from parts that are still wet or putrid. And this elucidates a circumstance very often noticed, viz., that neighbouring places—especially high and low lands lying near each other—change their character in respect to salubrity upon the occurrence of rains. The low grounds, which had previously been very dangerous, become healthy when they are flooded over; and the higher lands, which are made wet, and which rapidly dry again, produce the malaria abundantly. For the same reason, the edges or borders of swamps, which, of course, expand or contract according to the wetness or dryness of the season, are more unsafe than their centres. The drying and half-dried margins of the purest streams may be prolific of the evil when, from want of confining banks, these margins have been flooded by the rising of the waters." *

When the high lands become wetted by the rains, the soil becomes saturated, and the superabundant water runs off into the lower grounds. The water that remains is soon after evaporated, as the soil under a high temperature soon becomes heated during the day, whilst, during the night, the evaporation still continuing, reduces its electric tension very much. When the low lands are flooded, they become more salubrious, because water, in a large body, evaporates but slowly; but when the greater part of the water disappears, and leaves the surface, then the sickness returns, because a copious evaporation is now produced, and the electric tension is reduced. The reason why the borders of swamps are more unhealthy than their centres is that the wet or saturated soil around them causes a much

* Watson's Practice of Physic, vol. i.

larger amount of evaporation than their centres which are covered with water.

Dr. Watson mentions certain observations which were made in connexion with the barracks in English Harbour, in Antigua. They corroborate the statements regarding the salubrity of dry heights, and the insalubrity of places lying low and damp.* He states "That there is no observation more general than that, in malarious places, agues and remittent fevers abound more in hot and dry years than in those which are cold and moist. And this influence of temperature it is which mainly determines the differences observable in regard to these fevers at *different elevations* and in *different seasons* of the year. In the higher grounds of the West Indies, *agues* occur as in this country: as you descend, and the mean atmospheric temperature increases, *remittents* are met with; and in the lowest and hottest parts the fever becomes *continued.* The following instructive facts are stated by Dr. Ferguson:—In 1816, the British garrison of English Harbour, in Antigua, was dispersed in three separate barracks, on fortified hills surrounding the dockyard. One of the barracks was on an eminence named Monk's Hill, six hundred feet above the level of the marshes. The other two were situate on an eminence called the ridge, one at the height of five hundred, and the other at the height of three hundred feet. So pestiferous were the marshes among which the dockyard was placed that it often happened to a well-seasoned soldier coming down from Monk's Hill, and mounting the night guard in perfect health, to be seized with furious delirium while standing sentry,

* Watson's Practice of Physic, vol. i. p. 719.

and to expire within less than thirty hours after being carried up to his barracks, with a yellow skin, and having had black vomiting. Those in the barracks on Monk's Hill, *who did not come down*,—the superior officers, the women, children, and drummers, —had no fever of any kind. Seventeen artillerymen, in the barrack at the height of three hundred feet, did not come down to the night guards. (We shall see hereafter that malarious places are always most dangerous *at night.*) Every one of these men was attacked with remittent fever, of which one of them died. At the barrack on the top of the ridge, at the height of five hundred feet, there scarcely occurred any fever worthy of notice. Thus, *in the same place*, the malaria, in the level plain, caused continued fever, resembling, and, I believe, identical with, yellow fever; at the elevation of three hundred feet, it gave rise to remittent fever; and, at the height of five or six hundred feet, its influence was scarcely felt at all."

It is found in all epidemic localities that fever assumes various grades of severity in proportion to the elevation of the land where the affected are placed. This is represented in the above extract. In the highest situations, there is little or no disease; if any, it will be mild intermittents; and, at a certain point lower, there are remittents; while, at the lowest, the fever is continued, and is often yellow fever. It is not the elevation merely that increases the salubrity. It is the superior dryness of the situation. If elevation alone were effectual to secure a healthy situation, Seringapatam would be pre-eminently so, as it is 2000 feet above the level of the sea, yet it is far from being salubrious. This is accounted for by its being surrounded with swamps. The barracks on the heights, as at Freetown, Sierra Leone, are, in a great measure, insulated, and will be in a more positive condition, in consequence of the greater dryness and the smaller amount of evaporation, as the water cannot lie on the hills to carry off the electricity while being raised in evaporation. It is observed here also that the change is greatest at night, as was illustrated in the case of the poor soldier who kept guard at the foot of the hill. The artillerymen seem to have kept guard during the day, and were not injuriously affected. As has been already observed, the cause of the less danger during the day is, that the sun keeps the locality in a positive condition, in spite of the large quantity of electricity which is carried up by day; and there is no exaction from the body. At night, the circumstances are greatly altered. The electricity, which has been absorbed during the day, will be all carried up by the evaporation which continues after sunset, and, in place of a positive state of the soil, it will become highly negative, and abstract electricity from the animals in contact with it.

It is the opinion of the greatest number of those who have observed the remittent and yellow fever of the African coast, that the one complaint is just a modification of the other, and that the intermittent is merely a type of the same disease, and the result of a common cause. The operating influence, although the same, may be made to act in any measure—a less amount for the milder form of the disease, and a greater for the more virulent. The operating cause, although the same, may produce different manifestations in different places, and in different individuals, according to the peculiarities of their habits and constitutions. The same cause may produce the intermittent of the temperate zone, and the remittent and yellow fever of the torrid zone. The advocates of marsh miasm are of opinion that the poison is the same in the fenny counties of England, the large steaming marshes of Trinidad, and the dismal swamp of Upper India, which the very beasts instinctively forsake at the dangerous season, to return when evaporation has raised the water which causes the deadly moisture.

The difference in the type of disease may depend on the amount of impression made on the nervous system—on the amount of nervous power abstracted. This will be modified by causes affecting individual cases. The scrofulous and the dissipated will be more easily and more severely affected than the robust and temperate. The ordinary intermittents of swampy localities, in the temperate portions of the earth, are caused by a less abstraction of electricity from the system than that which causes the remittents of the warmer regions. The different effects produced on the human body by the malign agency of evaporation from swamps, in various regions of the earth, may be arranged in three divisions, according to the intensity of the disease. There is the intermittent of the temperate regions, the remittent of a warmer clime, and the yellow fever of the torrid zone,—all considered by some to be different types of the same disease. The intermittent of the temperate portion of the earth is produced by a less abstraction of electric power than happens in the other two, as the shock is not so severe. There are the chilliness, languor, debility, and other symptoms characteristic of the other two manifestations of the disease; but in this they are not manifested so violently. The nervous system is by turns able to go on and perform its assimilating and depurating functions, at one time tolerably well, but at others imperfectly, the blood becoming contaminated, and giving rise to deranged secretions. The pains in different parts of the body may be produced by the altered condition of the blood, passing with more difficulty through the capillaries. The heart is called into stronger action to propel the altered blood through the minute vessels. The sickness, bilious vomiting, &c., arise from the vitiated secretions, the result of the previously vitiated blood.

CHAPTER VI.

ON VARIATIONS OF ELECTRIC TENSION AS THE CAUSE OF PLAGUE.

Plague is another of those diseases which decimate the inhabitants of certain regions of the earth. It has certain peculiarities in common with the other pestilential diseases. There is, indeed, a striking uniformity in the principal characteristics of these diseases. There is the same sudden breaking up of the powers of life—the same tendency to dissolution. However they may vary in their external manifestations, whether yellow or purplish in the skin, or pustulous, or carbunculous, involving deeper tissues on the surface, there is a manifest resemblance in the principal characteristics of these diseases. The yellow fever of the African coast, the septic pestilence of Syria and Egypt, and the cholera of all the rest of the world, have in common the same destruction of vital resistance, and reduction of the power of cohesion of the tissues.

Though local causes may be found to account for the distinctive character of each pestilential disease, yet their general manifestations point to one great operating cause that must produce them all; and what other element in nature, more than electricity, could possess such an agency, could exert such a power? Electricity is the great binding principle in all inorganic matter; and on the principle of analogy, it is legitimate to conclude that it acts on organic matter after the same manner, communicating power to the nerves to support the cohesion of the tissues of the living body; and when by disease, or any other debilitating cause, the power of acquiring electricity—the binding principle—is reduced, and an agency applied to withdraw from the already small stock of electricity, there is then produced a high state of susceptibility to disease.

As in other formidable diseases, so in plague, there is a sudden and severe impression made on the nervous powers. There are first chills and rigors, and immediately follow the faintness and loss of power. Not only do the nerves of the muscular system become diminished in power; there are evidences that the nerves of the capillaries also lose their tone, and that enervation of the capillaries of the organs of secretion, as well as of assimilation, takes place, and hence the epigastric tenderness. The circulation soon becomes vitiated, because the organs of excretion are unable to throw off the impurities of the blood, in consequence of which this fluid is so altered in its composition as to make it ill adapted to pass through the capillaries; and when the force of the heart is strong enough to send it forward, it may cause the rupture of their delicate walls. Wherever these vessels are most attenuated, they will most readily give way. Those which enter into the structure of the cutaneous glands are delicate, and, when the more gross vitiated fluid is being projected through them, they easily dilate, and ultimately burst, as they cannot resist the force of the fluid which circulates within, this being besides more irritating in its composition than when in its healthy state.

In the following extract, Dr. Copland states, that "in plague both the blood and the capillaries have undergone a change. The hæmorrhages which were so frequently remarked in various countries where this pestilence prevailed, and soon occasioned death, were obviously the result of the vital dissolution of the structures and of the crasis of the blood; the inflammation said to have existed being a state of asthenic vascular congestion with sanguineous exudations, or inflammations of a gangrenous nature, owing to a rapid loss of the vital power of the capillaries. That such was the case in a remarkable degree, as respected the capillaries, the tissues, and the blood itself, was evinced by the rapid discolouration, the purplish hue, and the loss of sensibility of the affected parts. There was a a loss of vital cohesion throughout the whole frame, those tissues and structures, as the mucous, the cellular, the glandular, and the parenchymatous, that possess the least density, and the capillaries supplying them, most rapidly and most completely undergoing this septic alteration."*

The leaden and cadaverous hue of the skin may depend on the adulterated condition of the blood, consequent on the retention of the excretions, which, in a healthy condition of the system, would have been carried off. The pain in the head, and giddiness, may depend on the blood passing with diffi-

* Copland's Dictionary, Art. "Septic Pestilence," sect. 12.

culty through the capillaries, as these small vessels become distended from the want of adaptation of the fluid circulating within, to the small calibre of these very little vessels. The action of the heart may be hurried, as well from the increased difficulty of pressing the blood through the vessels, as from the unnatural stimulation of the vitiated blood on this important organ. On the physical change of the circulating fluid, and consequent effect on the capillaries, may depend the principal phenomena constituting plague, as well as those constituting remittent or yellow fever. The congested condition of the small vessels all over the system will cause distress and severe suffering in almost every part of the body. There is also that depression of the vital powers, in this disease, peculiar to the pestilential diseases; but there is especially, in the case of plague, a breaking up of the organic and glandular systems of the body, the capillaries appearing to burst and break up, and cause the disorganised appearances which are displayed both in the internal organs and in the cutaneous system. It is the breaking up of the capillaries of the skin which constitutes the petechial eruption found in bad cases of this disease.

Plague may be traced to depend on the very same cause which produces the diseases already mentioned. The topography of the countries, where it may be considered endemical, presents the same peculiarities as are exhibited in those countries where remittent and yellow fevers prevail; but the former are operated on in a less active manner by the heat of the sun,—are less subjected to sudden and powerful variations of electric tension.

In the torrid zone, the action of the sun on the water, in a swampy soil, is so intense as to produce an immense amount of evaporation in a very short time, and cause, at the same time, a very great alteration in the electric tension. In the more moderately heated regions, which are the haunts of this disease, the process of evaporation is proportionally slow, and the effects on the animal body less powerful. This is made evident by the longer continuance of those symptoms which are usually reckoned those of incubation. But the effect will be very different in different individuals. It is well known that, in all communities and nations, there are great varieties of constitution and condition—the greatest difference of susceptibility to become affected with disease. There are the healthy and robust, the well-fed and those provided with comfortable habitations. There are the feeble and the scrofulous, the ill-fed and those who have damp or ill-assorted abodes. There is evidently a wide difference between these two classes in regard to susceptibility to disease. The vigorous vital manifestations of the one class will enable them to resist even strong influences for evil; but the languor and feebleness of the other will cause them easily to succumb to the operation of agencies which would scarcely affect the former. People will be very variously affected, according to individual susceptibility and the intensity of the malign influences which are brought to bear upon them. In a large number of cases, the powers of life will be maintained in the most vigorous manner, and will not be affected by the most unfavourable impressions of the most morbid influences to which they may be subjected. In this class will be comprehended all those who are found to continue well, whilst their neighbours are cut down by a prevailing pestilence. On the principles here maintained, the elimination of vital electricity will be so abundant that a strong negative power may be made to act upon them without any injurious effect, as there is such a quantity evolved as more than meets the demand of the abstracting influence on their nervous powers.

Another class of a community exposed to pestilential influences may have as much vigour, with the help of precautionary measures, as to enable their constitution to resist the morbid impressions of the abstracting power; but they may feel occasional indications that there is some unfavourable agency operating on the locality in which they are placed. Another class may have less vigour of their nervous powers than the preceding, and may be unable to withstand the abstracting power of a strongly negative region, and, by degrees, be reduced to a point beyond which the integrity of the vital organs cannot continue, and will ultimately become victims to the prevailing disease. The above is the manner in which the incubation is produced; and the length of time occupied in this process will depend on the amount of the vigour of the constitution of the individual. Those whose nervous powers have never been very vigorous, and those whose constitutions have been shaken by dissipation, or who, by any other means, have wasted their bodily powers, have no strength to keep the system fortified to resist the abstracting power of a strongly negative influence, but will speedily succumb, and become the victims of pestilential disease.

The longer the question is examined, the more clearly does it appear that it is the same agency which operates in every region of the world in producing disease; and that the severity of any specific disease depends on the strength of this one agency which is brought to bear on the individuals affected. Whilst yellow fever is the product of a strongly operating influence, and prevails on the sea-coasts of countries in the torrid zone, where electric variations are remarkably great and sudden, the plague is a disease which prevails in situations which are of such a character as to produce less violent and sudden, but more continuous and not less fatal effects. On examining the regions of the earth in which this disease prevails, we find the conditions of the soil the same with regard to the facilities for evaporation; and in proportion to the raising of the vapour, there will be variation of the electric tension.

In the torrid regions of the earth, the sun sends down his rays in a vertical direction twice in the year, and in this way a large concentration of electricity is communicated during each diurnal visitation; but this is not retained, as on the diurnal withdrawal of his rays a rapid escape of the electric fluid absorbed during the day takes place, when the soil is saturated with water, and this escape is accomplished whilst the water is being evaporated. There is thus produced a more negative condition of the earth during the night than during the day; and the greater the amount of electric variation between the night and the day, the greater will be the danger. In those countries bordering on the torrid zone, but not in it, there are fewer of the vertical rays of the sun communicated, and there will then be a proportionally less amount of evaporation, and consequently the progress of the operation will be less sudden and slower. This slower evaporation, because of the smaller draft of electricity from the earth, will produce a less severe effect on the nervous powers of those who are exposed to its influence than on those exposed to evaporation within the torrid zone, where the variations of electric tension are so great between day and night. It is in those countries whose shores are washed by the Mediterranean Sea that plague is most frequently endemic; and its prevalence can be traced to the agency of evaporation, and the facilities which exist to produce it,—such as the proximity of swamps, or the analogous condition of the banks of rivers after being overflowed by inundations. Many facts narrated by observers on the spot, whilst the pestilence raged, demonstrate that the disease was most virulent always where evaporation was most intense, and that it gradually ceased in proportion as the soil became dried.

Plague is a disease which has been known from the most remote period. The Arabian physicians of an early age were familiar with it; and Hippocrates makes mention of it, tracing it to the same cause to which it is ascribed at the present day. It was known in London, and made great devastations among the inhabitants; its ravages being felt also among the population of different parts of England. Happily this disease has never prevailed in this country, since civilisation has furnished the people with comfortable habitations, and agriculture has drained the soil of moisture with which it was saturated, and has drawn off the water from the swamps, and that occupying large tracks of the hollows. It is not likely that it will again visit this country until the inhabitants degenerate into their former condition, and till the country becomes a waste, and the hollows are converted into swamps. It is unfortunate for the success of the search after the remote cause of this disease, that the attention of the inquirer is so much occupied with the question whether this disease is contagious, or whether it depends on some unknown agency emitted from the soil. When the mind is left unfettered by the preconceived opinions which rest on bare assumption or gratuitous hypotheses, it has more chance to dive into the abyss in which the truth has long been hid. Whether an inquiry in the direction here indicated will bring truth up from the abyss, must be determined by future experience and observation; but there will be no difficulty in demonstrating that plague arises from the same cause that produces other diseases. This can be done by collating the facts connected with the topography of the locality, the condition of the soil, and the state of the elements when plague prevails. The modifications which characterise the various diseases which appear in many parts of the world seem to depend on the amount and intensity of the agency. They depend on the strength of the agency which is brought to bear upon the nervous system to abstract its power. According to this principle, the abstracting power operating on the body to produce yellow fever is stronger and more sudden than it is in producing plague; that is, that there is a more sudden and larger abstraction of nervous power in yellow fever. The changes in the blood are more speedily produced, and hence the earlier and more violent rupture of the capillaries, in yellow fever than in plague.

The difference of temperature in the two regions where plague and yellow fever respectively prevail may account for the difference of the manifestations in each disease. There are in the regions which are known as the haunts of yellow fever great facilities for alteration in electric tension. The yellow fever requires a higher temperature and other good circumstances for producing speedy evaporation. The drying of the soil after the rainy season, in localities near the coast in the torrid zone, forms the most favourable condition—a great alteration of electric tension—for the production and development of yellow fever.

In the localities which produce the plague, on the other hand, there are not the same facilities for speedy evaporation. They are more like those which cause intermittent fever. It seems to require a less negative condition of the earth to produce plague than yellow fever, and a greater negative condition to produce plague than intermittent fever. If the swamps of the fenny counties of England were transferred from that country to the banks of the Nile, they would produce plague as readily as the muddy soil near the great river of Egypt. Writers, from very early times, have connected the prevalence of plague with a moist and unsettled condition of the weather. Dr. Mead, in 1767, writes as follows:—"In Ethiopia, those prodigious swarms of locusts which, at some times, cause a famine by devouring the fruits of the earth, unless they happen to be carried by the winds clear off into the sea, are observed to entail a new mischief upon the country when they die and rot, by raising a pestilence; the putrefaction being heightened by the excessive intemperance of the climate, which is so very great in this country that it is infested with violent rains at one season of the year for three or four months together; and it is particularly observed of this country, that the plague usually invades it whenever rains fall during the sultry heats of July and August, that is, as Lucretius expresses it, when the earth is 'intempestivis pluviisque et solibus icta.' Now, if we compare this last remark of the intemperance of the climate in Ethiopia with what the Arabian physicians, who lived near these countries, declare—that pestilences are brought by unseasonable moistures, heats, and want of winds,—I believe we shall be fully instructed in the usual cause of this disease, which, from all these observations compared together, I conclude to arise from the putrefaction so constantly generated in those countries, when that is heightened by the ill state of air now described, and especially from the putrefaction of animal substances."

In those remote ages, and amongst a rude class of people, it is improbable that they had cultivated that providence which might have enabled them to be affected as little as possible by the loss for a single season of the fruits of the earth. The destruction of the produce of the ground by these swarms of locusts had more to do with the production of the plague, by the famine that arose among the inhabitants by the loss of their crops, than by the putrefaction of the dead bodies of these insects, that eat up the food of the people. The famine would reduce the strength of the inhabitants, by the want of food, and by causing an arrest on the internal chemical changes which take place during digestion and assimilation. In this condition but little electricity will be eliminated, and that little will be abstracted by the negative condition of the earth, thus rendering the nervous system so weak as to be unable to elaborate from the blood the excretions to be thrown off, and the nutritious depositions to be laid down; and hence the capillary congestion which results from vitiated blood, and which may cause the glandular swellings and petechial eruptions in the mucous and cutaneous surfaces. The putrefaction which was the result of the dead locusts may have been more accidental than actually prejudicial, as it is found that, in the absence of moisture, the decomposition of animal matter is quite innocuous in producing febrile diseases. It is found that people in the vicinity of slaughter-houses, where there are large quantities of animal matter in all stages of decomposition, and who are exposed to it continually, suffer no unfavourable consequences. It often happens, too, that, in the absence of dead locusts, this disease occurs with as much virulence when there is merely hot, rainy, intemperate weather. This appears from what the Arabian physicians state. In the absence of all other apparent causes, some observers have been guided less by an appeal to science than to the sense of smell. There cannot but be mischievous results from the operation of a concentration of certain gases, the products of decomposition, as indeed is occasionally manifested by the exposure of an open grave in a hot climate. It has been known that all but instant death has been produced by the concentrated products of the decomposition of a recently dead body; but the very diluted condition in which these gases are found in the open fields, such as might result from the dead locusts, could not possibly, or was most unlikely to have a serious effect on the human body.

In another paragraph, Dr. Mead takes up for consideration the effect of temperature in the production of plague. "In general, a hot air is more disposed to spread contagion than a cold one, as no one can doubt who considers how much all kinds of effluvia are farther diffused in a warm air than in the contrary. But, moreover, that state of air, when unseasonable moisture and want of winds are added to its heat, which gives birth to the plague in some countries, will doubtless promote it in all. For Hippocrates sets down the same description of a pestilential state of air in his country as the Arabians do of the constitution which gives birth to the plague in Africa. Mercurialis assures us the same constitution of air attended the pestilence, in his time, at Padua; and Gassendus observes the same in the plague of Digue. Besides, it is easy to show how the air, by the sensible ill qualities discoursed of in the last chapter, should favour infectious diseases by rendering the body obnoxious to them. Indeed, other hurtful qualities of the air are more to be regarded than its heat alone; for the plague is sometimes stopped, while the heat of the seasons increases, upon the emendation of the air in other respects. At Smyrna, the plague, which is yearly carried thither by ships, constantly ceases about the 24th of June, by the clear and dry weather they always have at that time; the unwholesome damps being then dissipated that annoy the country in the spring. However, the heat of the air is of so much consequence, that if any ship brings it in the winter months of November, December, January, or February, it never spreads; but if later in the year, as in April or afterwards, it continues till the time before mentioned. But, moreover, what was said before of some latent disorders in the air having a share in spreading the plague, will likewise have place in these countries, as the last plague in the city of London remarkably proves; the seeds of which, upon its first entrance, and while confined to a house or two, preserved themselves through a hard frosty winter, and again put forth their malignant quality as soon as the warmth of the spring gave them force; but at the latter end of the next winter they were suppressed so as to appear no more, though in the month of December more than half the parishes were infected."

"Nor ought this caution to be omitted, that when the contagion has ceased in any place, by the approach of winter, it will not be safe to open a free trade with it too soon; because there are instances of the distemper's being stopped by the winter's cold, and yet the seeds of it not destroyed, but only kept inactive, till the warmth of the following spring has given them new life and force. Thus in the great plague at Genoa, about fourscore years ago, which continued part of two years, the first summer about 10,000 died; the winter following, hardly any; but the summer after, no less than 60,000. Likewise, the last plague at London appeared at the latter end of the year 1664, and was stopped during the winter by a hard frost of near three months' continuance; so that there remained no further appearance of it till the ensuing spring."

The doctor states here that a certain elevation of the temperature, when the air is in a moist condition, produces, or rather causes, the spread of plague; but a still higher temperature causes it to cease. He mentions the very day that it is expected to leave, and that it is driven away by the clear, dry weather which prevails at this time. The clear, dry weather, here mentioned, depends on the condition of the soil. The surface of that portion of the earth has become so dried as to leave no water for further evaporation, and hence the dry condition of the air. The same effect is produced in an opposite condition of the temperature. Extreme cold dries the air, and prevents evaporation as effectually as long-continued heat. Dr. Mead states that the plague is brought to Smyrna in ships, but does not mention any particular ships that made the importation. He does not mention what it is in the dry air that makes it unfavourable to the spread of plague. Even in the temperate climate of London, temperature has had its influence. It does not appear that the temperature had ever been so elevated as sufficiently to dry up the soil, and thus prevent evaporation; but the frosts of winter are stated to have arrested the plague. The air, dried either by the cold freezing the ground, or by long-continued elevated heat putting a stop to evaporation, is a bad conductor of electricity, and will withdraw this fluid neither from the earth nor the animals moving on it. As soon, however, as the heat operates on the frozen soil, it is rendered moist as before the frost, and evaporation begins; the electricity is withdrawn, and the situation thus operated on will again be placed in a negative condition. The disease is stated to have put forth its malignant quality *as soon as the warmth of the spring returned.* Possibly, after this, it might continue till the soil was sufficiently dry so as to yield no more evaporation, or till all the weak and susceptible among the people were carried off.

In a paper in the *Edinburgh Medical and Surgical Journal* for 1822, Mr. Coventry states the first impressions made on his mind, on seeing a fever that prevailed in the back settlements of North America, about half a century ago. It presented, in its features, many symptoms like those of the plague of the Levant. On more close inspection, however, the disease was found to be yellow fever. There is probably no other region of the world so circumstanced as the countries comprehended under the designation Levant; none that have the same peculiarities of climate, both in regard to dryness and humidity, as well as topographical construction; and, on the principles here advocated, it is because of these that plague is endemical.

In those regions where yellow fever is endemical, it is the effectual wetting of the dry soil, and the hasty drying under a burning sun, that produce the phenomena of this disease. In those regions, on the other hand, which are frequently visited by plague, the wetting is as sudden, and, in some places, more effectual, but the drying is less rapid, but more continuous. In the former-mentioned disease, the abstraction of vital electricity is larger, the shock to the system greater and more sudden, and the course of the disease shorter. In the latter disease, the abstraction of vital electricity is not so large in quantity, but it is more continuous, and the course of the disease is more protracted. It requires a different amount of agency to produce respectively plague and yellow fever. The land in the unreclaimed regions of the back settlements of North America, with a stiff and unabsorbing condition of its surface, will present a wet expanse to a burning sun, and produce quick evaporation, readily placing the locality in a low state of electric tension; and this negative surface will speedily abstract from the animals in contact with it. On the mud-banks of the Nile, and the other swampy regions of the Levant, there is, at certain seasons of the year, a slower but more constant evaporation—a more gradual abstraction of vital electricity.

There are, in the climate and topography of Egypt, those peculiarities which provide the evaporation, causing a negative condition of the soil for a great part of the year, and, on the principles here advocated, producing plague. The following extract is from Mr. Coventry's paper:—*

"The Nile begins to rise generally in April, and is at its height about the 25th of June. Egypt is generally an alluvial soil, with a flat surface. The resemblance is striking between the Delta of Egypt and the Mississippi territory in America. When the Nile rises so as to fill the ponds, and wash away the putrifying vegetables, the bazaars and shops are

* Ed. Med. and Surg. Journal for 1822.

opened in Cairo, and the Franks leave their confinement. They are then relieved from the terror of the contagious plague; the same as our citizens in American towns from the contagious yellow fever, when the first severe frost takes place; after which, you will see the inhabitants of the Carolinas and Georgia crowding south, after having spent the sultry months in the more elevated regions of the north and east. No wonder that the Egyptians deified the Nile; it affords them both bread and health, insuring crops, and arresting contagion. It has frequently struck me, in perusing the travels of different gentlemen, that whenever a place was famous for the frequency of the plague, there were marshes or pools in the neighbourhood, which, with us in America, would be suspected for sources of malignant fever. Let us consider for a moment the situation of Syria. It is, generally speaking, a plain, bounded on one side with mountains, on the other, with the sea, and interspersed with pools, and fringed with marshes; but here the plague is frequent. The French army became infected; but, when they entered the desert on the retreat from Jaffa, regained their health, and their wounds healed: there were no marshes in the desert. Egypt has been long celebrated for being subject to frequent, almost annual, attacks of the plague. Let us advert for a moment to the topography of this celebrated country. It is an extensive level tract of alluvial soil. Volney says, nothing more resembles its appearance than the marshes of the Lower Loire or the plains of Flanders. Again, all this part of Egypt is so level and so low that we are not three leagues from the coast when we discover the palm trees, &c.; and beyond this, nothing is seen but a boundless plain, which, at different seasons of the year, is an ocean of fresh water, a miry morass, a verdant field, or a dusty desert. Again, a flat plain intersected with canals, under water for three months, verdant and boggy for three others, and dusty and full of cracks the remainder; a sun darting his rays from azure skies, almost invariably free from clouds; and winds almost constantly blowing. For six months of the year, the water of the Nile—the only water used in Egypt—is so thick that it must have time to settle before it can be drunk; and during the three months which precede the inundation, reduced to an inconsiderable depth, it grows heated, becomes green, fetid, and full of worms, &c. Along the coast of Egypt,—which, on account of its shallowness, can only be approached with boats,—at a little distance from the sea, is a string of fresh-water lakes; these receive the filth brought down by the Nile in its flood. The north wind, which blows the far greater part of the year, serves to prevent the river discharging its contents into the Mediterranean, where, by dilution, deposits might become harmless. The water is generally at its height about the last of June, at which time the whole country is submerged. When the Nile returns within its banks, every hollow or depression of the surface becomes a stagnant pool. Whether this depression is an original concavity, or has been the former course of the river, or the bed of an ancient canal, it affords a receptacle for the water, which, having no exit, is evaporated by the rays of the sun. The water has killed all vegetation, which now decays, mixes with the liquid, and gives its poisonous effluvia to the air. These tanks continue to pollute the atmosphere, longer or shorter, according to their depth: some having that effect till the season of the next flood, when the waters of the Nile put a period to their agency; others more shallow, having performed their duty, are dried up, richly covered with luxuriant vegetation, and are fully prepared for the same process next season. This infectious atmosphere becomes prevalent, first, in the month of November, and generally continues increasing in virulence till the inundation in June. Egypt is seldom refreshed by showers, but depends for moisture on the Nile, the overflowing of which is more regular than the transient passing of clouds."

"Now, it seems the plague begins at Stamboul about the time it ceases in Egypt. I do not know that we hear of a non-intercourse between the two countries during the following months; yet it is rarely imported into Egypt till November, when the ponds and marshes of that country have prepared the atmosphere for its reception. Egypt being now prepared for it, the plague begins to abate at Constantinople, where the frosts have arrested vegetable putrefaction. It rains now with uncontrolled sway over the alluvion of Egypt, where frost is not known, till the water which has fallen in Nubia and Abyssinia, conveyed by the Nile, again sweeps the surface of Egypt, and destroys the source of pestilence. The Franks then leave their confinement, the bazaars and shops are opened, and Egypt is again willing to part with the fell destroyer to the Porte, or some other quarter of the world. Although there may be exceptions to this rule, I believe it will be allowed to exhibit the phenomena of plague on a general scale. Constantinople is in latitude 41° 27′; Cairo, latitude 30°; which shows, that the probability is that different means may produce the same effect at the two places. It is not improbable that the excessive heat of Egypt would soon exhaust the moisture necessary for vegetable putrefaction, as the deserts on each side are found to be free from plague. Is it not remarkable that the plague makes its appearance at the Porte about the same time that the yellow fever does in our cities; that when winter sets in, either disease is scarcely heard of at these places? In Egypt, where it may be said there is no winter, the plague is arrested by the overflowing of the Nile. Do not these circumstances lead us to suspect that the nature of the plague is not yet fully understood by Europeans in general? Stupid and superstitious as the Turks may be, yet self-preservation has so powerful a hold on the human mind, that I strongly suspect they have experience on their side, for not believing in the contagion of the plague."

From the time that the waters of the Nile have subsided, after having overflowed the vast plains of Egypt, the country is described to be in an unwholesome condition, till the river pours forth its waters again, to convert the country into a large inland sea. So thoroughly wet does the land become, that it is scarcely ever perfectly dried, as the subsoil to a great depth is completely saturated; and though the surface be dry and arid, the subsoil continues to yield moisture. The reason why the country becomes healthy when it is covered with water is, that it is converted into a large lake or inland sea, and there is consequently comparatively little evaporation from its surface. The people are obliged to resort to the higher and drier portions of the country, till the subsidence of the waters. So confident are the people of their safety, that they go freely out of their confinement. The safety of the people depends on their comparative insulation, so long as the waters continue at their full height; but very soon after the waters disappear, and the country is left completely saturated with water. So soon as the surface is dry enough to be walked upon, and when it is covered with a luxuriant vegetation, the people will be tempted to occupy the damp soil, the moisture of which is rapidly evaporating, keeping it in a constant negative condition, well fitted to withdraw the electricity from the animal body. That the elevation and dryness, and consequent positive condition, of the situations in which the people were placed, whilst the waters prevailed, had something to do with the increased salubrity, may be determined by the fact, that the French army, as soon as they entered the desert, regained their health, and their wounds were healed. This improvement in the condition of the soldiers was attributed to the absence of marshes. The desert is healthy, because it is always in a positive condition, yielding electricity, or nervous power, instead of abstracting it from the animal system. This is the character of deserts in all parts of the world. The inequalities which are found on the surface give rise, on the subsidence of the inundation, to many places where the water forms little canals and pools, which are dried up by the heat of the sun. It is in this drying process that the damp arises; and the greater the rapidity of the evaporation, the greater the danger. Now, the rapidity is greatest when the water has been all raised, except that which saturated what formed the bottom of these collections of water: the rays of the sun so heat the substance forming the bottom, as to cause the water in contact with it to be raised by a speedy drying process. This will place the soil in a thoroughly negative condition. It seems to require a long time before the soil is quite dried up, as Mr. Coventry states that all the water left by one inundation is not evaporated completely till the next takes place, and again ingulfs Egypt in a sea of fresh water. Though the country is thus covered with water, the air is tolerably dry, as the water does not fall directly in Egypt, but comes down the Nile from Nubia and Abyssinia.

It is mentioned, in the above extract, that the infectious atmosphere becomes prevalent, first, in the month of November, and generally with increasing virulence till the inundation in the succeeding June. This increasing insalubrity is as might have been expected. In the process of drying the soil, so long as the water is on the surface, the evaporation will not be very copious; but when it disappears, the subsoil being left saturated to a considerable depth, the comparatively dry surface becomes much more heated by the rays of the sun than when covered with water, and the water of the immediate subsoil becoming very much heated is raised very speedily by the electricity which would otherwise remain in the soil, and keep the locality in a positive and consequently salubrious condition. When the heat is sufficiently intense and long enough continued to dry up the soil, then the plague disappears with the vapour which produced it. M. L. Ch. Roche, writing on the Plague, in the *Dictionnaire de Médecine et de Chirurgie Pratiques*, states that "as soon as the season of the inundation terminates, that of vegetation begins, and with it the plague reappears. The disease disappears in proportion as the heat becomes intense, and in proportion as another element in putrefaction is displaced—and that is humidity. Plague ceases completely when the earth is made dry by the heat of the burning sun. The country is cracked throughout its whole extent, as if to open its breast to the approaching inundation." The plague visits various countries of the Levant, but with less regularity and virulence than it does Egypt, just because the operating agency is endemical in the latter, and occasional only in the former. It is not wonderful that "Constantinople is sometimes the seat of this disease, as there are, in its vicinity, twenty square miles of marsh, surrounded with a level country. The complaint makes its appearance in June or July, and generally disappears in October and November; yet some cases are found through the season." Frost never fails to put an end to plague, and it does so at Constantinople; but in Egypt there is no winter, and consequently no frost. During frost there is no evaporation, and the air is consequently dry, as the freezing of the soil, although wetted, arrests evaporation as effectually as the drying of it by the intense heat of the sun. It is because contagionists cannot but observe that humidity has some influence in aggravating pestilential diseases, that they record its concomitance whilst they prevail. Though earnest in their belief that contagion is the mode by which pestilential diseases are propagated, yet they admit the possibility of their arising *de novo* when there is an outrageous combination of the elements. Dr. Copland, who is a contagionist, admits that certain conditions of the air, such as heat and moisture, greatly aggravate pestilential diseases. He states that* "It cannot be doubted that, if we admit the spontaneous generation of the pestilence, on occasions when all the circumstances concur most efficiently to this effect, that the towns and villages of Lower Egypt furnish them in the most marked degree; but it cannot be also admitted that they stand alone in this respect, for many towns situated near the shores of the Mediterranean present conditions almost as favourable to the production of this effect as those of Egypt." In this passage, the Doctor states, if it be admitted at all that the plague arises *de novo*, that the towns and villages of Lower Egypt give the best evidence of this. The towns in this portion of Egypt are all situated, less or more, within the influence of the river Nile. It is there that the causes exist in a pre-eminent degree, to favour the invasion of this pestilence. They are all exposed to the same wetting and drying of the ground around them, and it is not the wetting of a transient shower which would immediately be dried up, but the complete saturation of the soil. It is immersed for weeks together, so that the water will have penetrated through the soil to the very rocks. This will give rise to a persisting and long-continued evaporation, causing, under a hot sun, a great and frequently repeated variation of

* Copland's Dict. Art. "Septic Pestilence," sect. 107.

electric tension; especially that low state of tension which takes place at night, when the sun is withdrawn. It is not at all probable that a town out of Egypt, and situated on the shores of the Mediterranean, can be in the same state as those of Lower Egypt. There is no Nile to overflow the country around, and keep up a continual evaporation for months together. There may be marshes, which, however, could only in a modified degree represent the condition of the banks of the Nile; but they could not possess the baneful properties of that moisture producing an occasionally pestiferous region.

History, from an early age, bears testimony to the fact that a moist state of the air, arising of course from a wet condition of the soil, has been associated with plague.

Dr. Copland enumerates various causes which have been supposed to produce plague, but they are almost all more or less connected with existing facilities for producing evaporation. In his article on Septic Pestilence, he states that * "Local or endemic conditions have been much insisted upon by some writers, and by several of those who have communicated with the French Academy, on the subject of plague; these conditions especially:—the accumulation of animal exuviæ; the decomposition of dead animals; incomplete modes of human sepulture, and burying the dead in vaults and crowded churchyards, situated within or nearly contiguous to towns and cities; imperfect drainage, and the passage of decomposing animal fluids and excretions into cesspools, into a low,

* Copland's Dict. Art. "Septic Pestilence," sec. 128.

wet, and rich soil, or into canals, open drains, &c.; collections of animal and vegetable matters left to decompose in the air, surrounding low, damp, and ill-ventilated dwellings, or in narrow and crowded streets; living in cellars or in close apartments on the ground, and having merely the soil impregnated with animal secretions and the fluids from animal decomposition for a floor; adjoining marshes, estuaries, low grounds, subject to inundations; ruinous and obstructed canals, stagnant water, &c.; a deep, rich, and humid soil, accumulated for ages from the decay of animal and vegetable matter, and from the mud and slime produced by repeated inundations, and evaporation by a warm sun; scarcity, and unwholesome food; and the use of water contaminated by animal matter, by the decomposition of organized bodies, or by the infusoria, severally exert no mean influence in the development and spread of plague and other pestilences. It is seldom, however, that one or two merely of these conditions are found existing in a locality or town in the East, without being associated with others, or even with nearly all those now enumerated; and if they be singly injurious, as they must be admitted to be, how much more so must they prove when associated, and the emanations from them are elicited by heat, and accumulated in a humid and stagnant atmosphere. It is to the combination of a number of these, aided by moderate warmth and humidity, that many recent writers impute, as I have shown above (§ 106 *et seq.*), the generation of this pestilence *de novo*, and its endemic and sporadic existence; whilst others have maintained, in opposition to this view, that, so far from these circumstances having generated the plague, or given rise to sporadic cases, or to an endemic form of the pestilence, they have actually been unfavourable to the prevalence of it when it has been epidemic; and that quarters of cities, where they have been most remarkable, have suffered the least from it, on these epidemic occasions. It has been stated, even by the supporters of the origination of this distemper in these causes, that the Jews' quarters, and others the most filthy, and combining most of the conditions just specified, have suffered the least in various epidemics which ravaged Cairo, Smyrna, and other towns in the East; and an argument against the accuracy of their own views has thus been furnished by themselves."

To maintain that a hot, humid, and stagnant atmosphere, and, at the same time, a wet soil, are conditions which are unfavourable to the development of plague, is contrary to the observation of all the writers to whose works the author has had access. A filthy condition of a locality may quite possibly exist with a dry condition of it; and the Jews may accidentally inhabit a portion of the town which is in the best circumstances for avoiding the disease. Those writers who have entertained the views specified above must have allowed many facts, that have been pointed out by others, to escape their observation.

Apart altogether from the depressing agency of the gaseous emanations which result from the decomposition of dead animal matter, there is also active evaporation from grounds which contain a large number of dead bodies, such as a burying-ground. In consequence of the large quantity of fluid contained in animal remains, the continued addition of dead bodies keeps the ground thus occupied in a constant state of humidity, thereby giving rise to regular evaporation. The interruption of the water that ought to pass through drains, and its diffusion over a large surface, and a wet, rich soil present great facilities for evaporation. Canals, when filled with water, are not favourable to the production of moisture. Decomposing animal and vegetable matter are mischievous principally because of the fluid they contain, as it must be all raised up by evaporation. Low, damp dwellings are much more injurious than the operation of the decomposing organic matter outside, as the dampness of the dwelling will cause a continual exaction of vital electricity from the inhabitants of the house, to evaporate the water producing the dampness of the dwelling. Living in cellars implies being surrounded by dampness, especially when the floor is the bare earth, and is kept wetted. Marshes are known all over the world to be instrumental in producing diseases, and grounds subject to inundations are notoriously unhealthy, as is so frequently demonstrated by the periodical overflowing of the Nile. Stagnant waters, unless shallow and frequently dried up, are not injurious to health. There are numberless places where these are known to exist, without disturbance of the salubrity of the district. The ditches around walled towns are never complained of, till they become nearly dry, leaving the bottom saturated with water, causing the evaporation to be more active, and in this way becoming mischievous.

The accumulated débris of animals and vegetables in a humid soil does harm only in so far as it serves as a sponge to retain water till it is raised by evaporation; and the electric conditions of the surface are thus disturbed. The mud and slime, which are the product of inundations, act injuriously in the same manner. Unwholesomeness and scarcity of food hinder the internal elimination of electricity; and if persons, when famishing, are exposed to a powerfully exacting agency, a speedy breaking-down must follow. It is not easy to understand how organized bodies, taken in water, can be injurious, as they must be subjected to the decomposing operation of digestion. Dr. Copland states that "it is to the combination of a number of these (causes), aided by moderate warmth and humidity, that many recent writers impute the generation of this pestilence *de novo*." It is the humidity, or rather the evaporation alone, that gives rise to this complaint *de novo*, and it is this which causes its continuation. It is known that if the evaporation be made to cease, leaving all other supposed disturbing causes as they were, the disease will cease.

A report was given by a commission of medical men, by order of the House of Commons, in June 1819, on the subject of Plague, as to its contagiousness.* "Of twenty-two medical men who stated their opinions, twenty considered that plague is contagious; and only two, that it depended on other general and atmospherical causes. They have incidentally mentioned some facts that will be useful to illustrate our subject. John Green, Esq., trea-

* Ed. Med. and Surg. Journal, in 1820.

surer to the Levant Company, who resided in Constantinople from 1774 to 1780, states that the lazarettos of England are old men-of-war, with houses built upon them, like an ark. The sides of these houses are open like a brewhouse, with shutters, and the floors are all open gratings, in fact; so that the ventilation is excessive on board these vessels in Standgate Creek—greater than it is possible to give on any building on shore. The ships also swing with the tide; that is, when the tide turns, they change their sides to windward every six hours." And Dr. Maclean states, on the authority of Dr. Carnhanha and of Dr. Grieves, superintendent of quarantine at Malta, that "no case of plague had occurred in the lazaretto for fifteen years, nor, in the plague of 1813, was any officer of the lazaretto affected by the disease. On being asked if he was aware that, in the towns of the East, the Turks suffer in a greater proportion than the Christian population, he answers, 'that he knows the fact to have been so represented by Christian travellers in the Levant, but that he considers this as a mere assumption.'"

These houses, built on old men-of-war, are of necessity made of wood; and the people, constantly confined to then, must be well insulated, as wood is a bad conductor of electricity, and will, consequently, make no draft on their nervous power. The free ventilation would not be injurious at the usual temperature of these regions, as it is seldom uncomfortably depressed. It is a good arrangement to have the place of residence *above* the hull of the man-of-war, as there might be bilge-water in the hold, which would expose the people to evaporation, and thus disturb their electric relations. A residence near a pestilential locality, anchored at a small distance from shore, without a single officer or resident being affected, is a satisfactory proof that insulation is a protection against this disease. The assumption that the Christian population suffers less than the Turks may be correct on this ground, that these last may be less comfortable in regard both to housing and hygiène than the Christians. Dr. Maclean adds his testimony to the fact that "Constantinople is never totally free from plague."

Dr. Granville mentions that* "in Constantinople, Smyrna, Egypt, and Syria, the Franks, who can afford it, shut themselves up during plague; and he never heard an instance of such persons being infected, where the seclusion was perfect." The houses where people reside, and in Turkey especially the houses of the Franks, will be dry, and in consequence of this, in a great measure, will they be insulated, and not exposed to the electric variations which are produced by the evaporation outside their dwellings. There could be no risk to these people by coming out of their seclusion, and taking an airing during the sunshine, when it is at its hottest, as then there would be a larger supply of electricity from the sun's rays than is required for the process of evaporation, and this would contribute to keep the animal body in a positive condition.

Mr. Edward Hayes bears testimony to the influence of the extremes of temperature in causing the disappearance of plague. He states that† "at Smyrna the disease generally begins in March or April, and ends in August at the latest; but great

* Ed. Med. and Surg. Journal for 1820. † Ibid.

cold or heat commonly arrests it." That is, the great cold arrests it, by sealing up the moisture in the ground; but the disease will return, as soon as the heat returns to renew the evaporation. The great heat will arrest this disease, by raising all the water from the soil, till none remain for evaporation; but the disease will again appear, when the soil is thoroughly wetted, and evaporation actively renewed.

The principal deliverance of this Parliamentary commission of medical men was, *that the plague is a contagious diseasc, and requires the continuation of the quarantine laws.*

CHAPTER VII.

FACILITIES FOR EVAPORATION, AND CONSEQUENT VARIATION OF ELECTRIC TENSION, THE CAUSE OF PESTILENTIAL DISEASES ON BOARD SHIP.

There is another region, far from the fixed habitations of men, and far from the instrumentalities which are its supposed indispensable causes, where pestilential disease makes its ravages. In the waste, howling wilderness of the ocean, in the tiny bark of the seaman, driven and tossed by the wind, there the fell destroyer of our species strikes down its victims; the master and the men are alike unspared. No class of men more than this requires our commiseration, for help cannot easily reach them. Before and behind, on this side and on that, there is nothing but a watery waste, as far as the vision can be carried, even to the receding horizon: their cry can bring no human aid. It is only upward now that they can look; but this looking must be with a living trusting, and then the looking will not be in vain.

There will be little difficulty in making it appear that evaporation on board ship, as well as on shore, is the cause of disease. It is not surprising that ships contain water, as they are continually floating on this element, and it is pressing on all sides, ready to enter as soon as the least crevice is opened; and in boisterous weather, it may be shipped. The reviewer of a work on Malaria, by Dr. M'Culloch, in the *Medico-Chirurgical Review*, for January, 1828, states, that "The writings of Bancroft, Dickson, M'Arthur, and others, have completely established the important fact, that fevers of the most malignant kind have been generated by the action of water on various materials in ships' holds." The action of water on substances in ships' holds could not be of an active chemical nature, and there could be no hurtful emanation without decomposition. It is difficult to conceive the possibility of hurtful emanations from the mere action of water on wood, which is the most common substance that is found in the hold in contact with the water. But when the action of heat upon the water in the hold is considered, it is found that a process is instituted in the ship, nearly identical to what takes place on land, by the action of heat on the water of marshes, to cause disease among the people in their vicinity. The water in the hold of a ship does not keep still, like the water of a pool, but must shift on account of the motion of the vessel, occupying now one portion of the ship, and then another, keeping that portion of the bottom of the ship alternately covered with water, and left wet. The heat of the ship, that of the fire of the cook, that of the master's in the cabin, and that radiating from the men in their berths, will all contribute to cause the water on the wet bottom of the ship to evaporate. The vapour thus produced, if the walls of the ship be cold enough, and if the weather be wet enough, will condense and wet the internal timbers, and the bedding of the men. When the bodies of the sailors are enveloped in these moist coverings, there will be an exaction from them of the electricity which is being eliminated by the vital operations to supply nervous energy; and in proportion to the draft made on the vital powers by this abstracting agency, so will be the virulence of the resulting diseased manifestations. In a paper of the writer's, formerly alluded to, there is the following passage:—"Phenomena of an analogous nature may be observed in producing diseases on board vessels at sea. In tropical regions, the vessels at sea are often attacked with severe and deadly disease, although far removed from all kinds of miasms and emanations from the soil. The causes which operate in such circumstances must arise from the ship itself, or from the sea, which everywhere surrounds it. Nothing but the vapour of pure water can arise from the sea, by the operation of heat, and the evaporation can never be so copious as it is from burning land recently covered with rain. In considering the circumstances of the ship itself, we find that it is constructed of wood, and this material is a good non-conductor of electricity, and the crew of the ship are thereby nearly insulated. It is well known that a ship which is kept perfectly dry is much more favourable to health than one which is leaky and always damp. During the operation of washing the deck under the rays of a tropical sun, there is produced, from the great heat of the timber of the deck, a very speedy evaporation. From a conviction that an attention to cleanliness is required to prevent sickness on board vessels in hot climates, the masters take care to institute a regular routine of washing and scrubbing. I have heard of vessels which have suffered dreadfully from yellow fever, whilst the decks were being visited with watery ablution many times a day. On the contrary, where strict attention is paid to have the ship thoroughly dry throughout, sickness of the people is much more rare and more mild. Various speculations have been entertained to account for the prevalence of fever on board vessels at sea. Some suppose that the vegetable débris, which is sometimes left in the ship in a state of decomposition, emits fomites, and thus produces fever." Dr. Wilson, in his *Memoirs on the Fevers of the West Indies*, supposes that the wood, forming the interior of the hold of the ship, undergoes in tropical climates a great change, during which some of its constituent principles suffer decomposition, and pass off in a gaseous form. This change is manifested by the wood becoming dark, by its shrinking, and becoming denser in its structure, at the same time losing water, and by seeming to be partly charred. The extent to which this process is carried, and the nature of its result, Dr. Wilson represents to be modified by the previous condition of the wood, by the degree of heat, and, probably, by the interior arrangements of the individual ships. In a vessel newly built, arriving in the West Indies in the hottest season of the year, remaining for weeks in the harbour, with the hold cleared out, and heated by stoves, as was the case with "the Rattlesnake," the process of drying is speedily completed. According to Dr. Wilson, "fever, in such circumstances, appears early and spreads rapidly; but when it ceases, it returns not again. In a vessel, on the contrary, which arrives in the cold season, which is much at sea, and the hold of which is not dried by stoves, the process of decomposition is slow and imperfect, and may never be completed. In such a vessel, fever will never be severe and very fatal, but it will recur, and produce sickness and death, till the last day of her continuance on the station. These facts are confirmed by the phenomena of fever in many vessels in the West Indies."

From a want of confidence in the causes usually assigned as producing sickness on board ship, Dr. W. supposes that, by the decomposition of the walls of the ship, gases are formed, which may act as the mischievous agent. He does not mention, however, what he considers to be the mode of action of these gases on the human body to produce disease. He states, that whilst the drying and heating were being effected, fever appeared early and spread rapidly. There is, however, the same vagueness as to the mode of operation of these gases, as has been associated with what have been understood to be malarious emanations or miasms. There is an element in this operation of heating and drying of the ship which Dr. Wilson does not take into account, and that is evaporation. It is not possible to estimate the effects that would arise to the human frame from the gaseous products of the decomposition of wood; but on the principles here advanced, an intelligent idea can be well entertained, by supposing that the speedy evaporation of the water imbibed by the timbers of the ship, would withdraw from the ship, and consequently from the crew, the vital electricity; and hence would be produced a comparatively negative state of electricity, producing derangements and diseases in those exposed to its influence. In the case of the ship dried by stoves, there is a good illustration of what occurs on land. In those places which are naturally dry, but subject to occasional rains, fevers spread rapidly and are very severe while it is raining, and, more particulary after its cessation, during the evaporation which follows. Now this suffering is always concomitant with a copious evaporation. The sun acts the part of the stove, and, as soon as the earth becomes dry, the fever disappears, and continues absent till the next rainy season reproduces the condition favourable for evaporation. Again, in those vessels which are always kept damp by water in the hold, or otherwise, "fever will never be severe and very fatal, but it will often recur and produce sickness and death." This may be viewed as an illustration of what happens on land, in warm regions, in the vicinity of marshes. In those localities there are seldom severe and rapidly fatal diseases, but almost a constant sickliness in the form of intermittent fever, and other complaints. There is here the comparatively slow evaporation, and continued drawing off of the electric fluid from the earth and the objects on it, which impregnates the clouds, and in this way it may be carried to a great distance, to discharge itself in vivid flashes and terrific thunderings in a country which may already be well supplied, and thereby be put in a highly positive condition.

There are many facts which might be adduced, to show that diseases on board ship depend on causes connected with the ship itself. A striking fact is given in the following account by Dr. Wilson, of the insalubrity of a special portion of the ship. Its connexion with the appearance and progress of the fever, in different parts of the vessel, ("the Isis") is interesting.* "Confined at first to a small space, the disease begins generally in the vicinity of the pumps, and main hatchway, where the keel is most dependent, where water, draining from other parts, is accumulated, and where heat is most intense. Thus the first cases, and the greatest mortality, take place in the berths of the midshipmen, and marines, which in frigates are placed on each side of the pumps and main hatchway. Its subsequent progress depends on the trim of the vessel, and the inclination of the keel, from the horizontal position; the disease spreading in the most depending direction." These general inferences the author afterwards affirms, by a clear and curious collation of evidence, from the phenomena of fever, as it took place in the Rattlesnake, the Isis, the Pylades, the Ferret, the Scylla, and the Lively.

There is, in the circumstance of the first cases arising near the pumps, and hatchways, the security that they were in the dampest part of the habitable portion of the ship, and it affords a presumption, that it is not a dry ship, when the pumps are much required. Water, from a physical necessity, occupies the most depending part of the ship, and when the disease has its focus in the same portion of the ship, there are strong grounds for believing that there is a connexion between the presence of the water and consequent dampness, as the cause of the

* Ed. Med. and Surg. Journal for 1828.

disease. That this is the general experience in those Government ships which are damp, may be concluded from the statement, that six vessels, known to one medical officer as having this damp peculiarity, were unhealthy.

When we find that persons living near situations on the surface of the earth which contain water, and present facilities for evaporation, are less or more subject to disease, there is no difficulty in admitting the analogy between evaporation, and its effects on shore, and the same process on board ship. In the one case, the mischievous locality can be forsaken, but the poor sailor, shut up in his floating, pestiferous prison, must remain there, till favouring winds blow him to his haven, or the less favouring grim master free him from his hazardous bondage. The severity of disease on board ship has been found to depend on the facilities existing in it to produce evaporation. Ships in the seas of the torrid zone are much more exposed to the injurious consequences of dampness than those which are confined to the seas of the more temperate regions of the earth.

The reviewer of Dr. Bancroft's work on Yellow Fever, in the *Edinburgh Medical and Surgical Journal* for 1828, states that "Bancroft laboured hard to establish the fact, that the moisture, which is *always in the holds of ships*, and mixed with vegetable matter, undergoing in this climate rapid decomposition, is quite equivalent to a marsh on shore." It seems that not only water, but also sand, and mud, and stones, are found in the great majority of ships. Such a provision as this in the hold of a ship may be quite innocuous in a cold or temperate climate. but in the torrid zone, where everything is raised to a high temperature, the temperature of the water in the hold will be raised also, and that to such a degree, as to cause active evaporation; and the vapour thus raised must find exit, and for this purpose it passes up through the ship, keeping the air saturated with moisture. In this condition the air is a good conductor of electricity, and, being in contact with every object in the ship, will act as a conductor, and withdraw electricity from every individual; as all animals are positive compared with inanimate objects. However, one animal may be positive, and another negative, as contrasted with each other. Those persons on board ship, with a normal condition of the vital organs, the digestion sound, and operating vigorously, and the lungs well developed, and in good condition, will be positive, and have a large quantity of electricity to spare, and be able to bear a large amount of abstraction. On the contrary, persons affected with languid digestion, or disease of the digestive and assimilating organs, will scarcely eliminate enough of the vital element for the internal operations, and can have nothing to spare. One of the individuals first described is in the most positive condition, and would bear the abstracting power of the good conducting media that surround him, much better than an individual in the condition described second, who had probably too little of the vital fluid to carry on vigorously the assimilating functions themselves. This contrariety in the electric condition of persons in a ship's company, explains why one is affected by a prevailing illness, whilst another remains in good health.

Dr. Ferguson, in the *Medico-Chirurgical Transac-*

tions,* gives an account of the ship Regalia, on board which there had been a great amount of sickness. He describes the hold of the ship as containing "small stones, with a considerable mixture of mud, and other impurities, and when I examined it, it had been much fouled by leakage from the water-casks." The ship in respect to leakage was far from being a dry ship. Notwithstanding the condition of the ship, the people continued healthy, till they took into it a large quantity of green wood as firewood, when the ship was at Sierra Leone. About the same time, there was taken on board a large number of negroes, and afterwards they set sail to the West Indies. In a few days, sickness appeared among the people, and fifty-four died before they reached their destination. There were upwards of 793 negroes. In speculating on the cause of the disease on board this ship, Dr. Ferguson states, that "the cause of disease was therefore, I am clearly of opinion, to be ascribed to the green wood laid in at Sierra Leone, operating along with the foul ballast, to furnish, when impregnated with the gases arising from putrid sea-water, morbific miasmata, similar to those that on land arise from marshes, when exposed to the higher degrees of atmospherical heat." Dr. Ferguson very properly considers that the cause of the disease depended on the foul state of the hold, and on the green wood placed in it; but when he ventures to mention how these contents of the hold operated injuriously, he has recourse to the hypothetical agency, malaria—but how this acts, no one can tell. The principles here advocated can at least intelligently point out an agency potent enough to

* Med.-Chir. Transactions for 1817.

cause the evils. The mud and the water in the hold were injurious, in proportion to the amount of evaporation which they produced. The green wood was injurious on the same grounds. The latter, however, presented an infinitely larger surface for evaporation than the former. The radiation of heat from upwards of 800 individuals in a ship, and the heat of a tropical climate would act powerfully on the moisture with which the wood was impregnated, as well as upon the water in the hold, and these two sources of evaporation would keep the air of the ship in a continually moist condition, and thus capable of acting injuriously on the people. There would be amongst the negroes, as amongst other classes of men, a variety of constitution, with different susceptibilities to become diseased, and the living continuously in a moist atmosphere would cause the weakest of them to become readily diseased. The change of diet would cause derangement of the digestive organs. The vital actions, depending on integrity of the important functions involved in a right performance of digestion, would not be performed with that vigour which was required to enable the system to bear the abstracting influences of the negative forces which were produced by the moisture in the ship. In consequence of the imperfect performance of the functions of excretion, there might be retention in the circulating fluid of some of those bodies that ought to have been thrown out. The capillaries of the bowels, being in a state of irritation by the unusual ingesta, would cause the manifestation of diseased action to take place in the mucous surface of the digestive tube. The most prevalent complaint on board the ship was dysentery.

In an appendix to Dr. Ferguson's paper, a report of the condition of the ship is given by Mr. Mortimer.*

"We have shown in the history of the Regalia transport, that she continued perfectly healthy during the several weeks she was employed on the African coast, and until she shipped a quantity of green wood, cut down, and brought on board the same day. We have it in proof that fever made its appearance soon afterwards, that it prevailed with unabating malignity on her arrival at Barbadoes, where it was asserted she had imported, in the persons of black recruits, a highly pestilential disease.

"We have it furthermore in evidence, that, whilst at English Harbour, she underwent fumigation, as ordered by Commissioner Lewis, without the least effect in arresting future attacks, or their fatality; and that it was not until after her arrival in Carlisle Bay, where she was *completely cleared*, *and*, *with her hatchways closed*, *her whole hold exposed to the concentrated heat of many stoves*, *that fever ceased*."

When it is found that this ship continued perfectly healthy till the shipping of the green wood, there are strong grounds for believing that there must be a connexion between the green wood and the sickness of the ship. This is very satisfactorily brought out by the restored healthy condition of the ship, so soon as the hold was freed of all the green wood, and thoroughly dried. The heating by stoves was evidently the method by which the ship was restored to its former healthy condition. There was no change which the heating could produce, but that of removing the water that caused the ship to be damp. Whatever other effect than this was pro-

* Med.-Chir. Transactions for 1817.

duced by the heat was quite inappreciable. On subjecting any foul water to the action of strong heat, and condensing the vapour arising therefrom, there is nothing but pure water found to result. Then if the timbers of the hold of the ship be very filthy, there is nothing which can be drawn off, except the water with which the filth is combined. When we find a known, adequate, and sufficient cause of disease in the evaporation from the holds of ships, why adhere to the opinion that malaria is the cause, seeing that it rests on mere conjecture?

In the *Edinburgh Medical and Surgical Journal* for 1817 some observations are made by Mr. Birnie on diseases, which took place on board several Government ships, stationed in the West Indies. Of one, viz., the Antelope, he says:—

"Immediately after our arrival in this country, about the beginning of March last, when the inhabitants of Bridgetown were perfectly healthy, and no cases of fever on shore, at least I am certain that no one belonging to the ship had been near, or indeed had heard of any sick person on shore, a fever, characterized by all the symptoms which Mr. Pym has attributed to Bulam fever, made its appearance on board the Antelope, and since that period, 110 cases have occurred in her, of which thirty-one only have died; of those thirty-one, nine either lived entirely in the fore and after cock-pits, or messed, and consequently passed the greater part of their time there. None who had black vomit recovered; and of the thirty-one, seven only had black vomit; and of these seven, six were of the nine mentioned above, as living almost entirely *below*, where the atmosphere in this country is thick and heavy, and produces a peculiar hot sensation, on descending from above into it. The temperature is always about the same, is often below what it is on deck, and from the continual burning of candles, the crowding together of several people, the débris of pantries, and mess-rooms, not always exceedingly clean, together with the want of circulation of air, may have caused so great a proportional number of those who were obliged to mess or live below, to die and have black vomit."

From the description given of part of this ship's company having thus passed so much of their time under decks, amidst "the débris of pantries and mess-rooms," and in resulting dampness, the wonder is that disease did not attack the people long before they reached Bridgetown. But probably at sea the crew would not be so closely confined to the cockpit, as they would have to work the ship. There is no mention made of the condition of the hold, as to how much water it contained. When there was no suspicion entertained regarding the water as having to do with the cause of the disease, no notice would be taken of it. But when the air was thick and heavy, it must have contained a large quantity of moisture which will account for its apparent additional gravity, and the moisture arising from the ship would carry with it the electricity of the ship, and keep it in a low state of electric tension, abstracting nervous power from the people in the ship, especially from those who were nearest the focus of the origin of the vapour.

That it was true that the ship was negative, may be concluded from the temperature being colder under hatches in the ship than it was in the open air.

It is not easy to conceive how a small place, filled with living beings, who in health always radiate heat from their bodies, could be of a lower temperature than the open air. The electricity which ought to be retained to continue the vital operations, is abstracted and none is left for radiation. Of the seven severe cases which occurred in the ship, six were persons who lived almost entirely below. By living so constantly exposed to low electric tension, their nervous power would be so exhausted as to prevent the carrying on of the vital operations, and thus produce enervation of the capillaries. Then would follow a vitiated condition of the blood, a want of adaptation of the fluid to the tubes, and as a consequence, there will be a congestion of the capillaries, and ultimately destruction of these small tubes, in all parts of the body, as is found in yellow fever, or black vomit. There were many others who took ill on board who were not so severely affected as those that were attacked with yellow fever. There may have been persons of different susceptibilities, and some who may have had less of the abstracting power operating on them, in whom the consequent irritation of the blood would be much less severe, and the constitutional powers being less crippled, the purification of the blood would be accomplished by the amount of constitutional power which still remained. The ship's company, exposed to the same influences, may have all suffered just in proportion to the amount of the abstraction of their nervous power.

Mr. Birnie mentions the case of another ship, called Childers, and contrasts the condition of the two, both with regard to the state of the ships and the comparative sickness of the ships' companies.

"The lower deck of the Antelope, where the people mess, is always well aired, except in a heavy sea, which does not often occur in the West Indies,* and is always kept in an exceedingly clean state, which accounts for the disease not running through the ship's company, and for its comparative manageableness; but in the *cock-pits*, every person was attacked, except two seasoned hands; about one-half died, while, in the other parts of the ship not more than a fourteenth, viz., nine of the thirty-one, who died on board her, had either lived entirely, or messed in the cock-pits, and of the seven cases of black vomit, six were of those nine. The lower deck of the Childers, where the people mess, was dirty in the extreme. On lifting the hatches of the fore or after holds, a horrid, suffocating stench issued from them; it was confined, lumbered with lockers, and the heat increased by the fire-place being on it, it was in a nasty, filthy condition, and I do not recollect that it was attempted to ventilate it by wind-sails. This state of the vessel, the want of accommodation and attendance, and the sudden fall of the medical officers, accounts for the mortality on board of her, and for the disease attacking all her crew; only three escaped an attack, and *about half died.* Here we observe a remarkable coincidence between the extent and mortality of the disease in our *cock-pits*, and in the *Childers.* We see the influence of the climate modified by the different situation of the two ships, and by the different situation of the parts of the same ship."

* Ed. Med. and Surg. Journal for 1817, p. 334.

The exceeding cleanness of the lower deck of the Antelope, implies frequent ablutions of the floors of the lower deck. This giving rise to a regular process of evaporation, would effectually keep the ship in a low state of electric tension, which, added to the other depressing instrumentalities in the lower portion of the ship, would account for the great mortality in both ships. The filth of the lower deck of the Childers must have been impregnated with water, and the polluted condition of the air, which produced a stench in its ascent from below, must have been an injurious condition, by being loaded with carbon, and this, with the depression of the organic nervous power, would disqualify the secerning and excreting operations from doing their part in preserving the purity of the blood. It was remarked that in the filthy ship, and in the partially cleaned ship, the mortality was equal. The cleansing seemed to have no good effect on the ship Antelope. The evaporation during the frequent cleansing process in the Antelope would be as injurious as the wetness associated with the filth of the Childers.

Dr. McKinlay remarks, that "steam-ships are generally observed to have more cases of disease in proportion, and particularly more cases of severe disease, than sailing vessels, notwithstanding that the accommodation in the former is better." In steam-vessels there is almost always a large quantity of water and moisture in the working portion of the ship. This takes place from the leakage from the feeding pipes, and sometimes from the boilers. In some of the steam-vessels plying on our rivers, there is a provision connected with the engine to draw up from the hold the water which escapes from the pipes and valves connected with the engine. There must necessarily be a large surface in the neighbourhood of the engine and boiler kept in a moist and wet state, and this will give rise to constant and copious evaporation, when the fires are lighted and the boilers are heated. Government steam-ships, when on a cruising commission, sometimes put out their fires, and trust to their sails. When this takes place, there must be a very great reduction of the temperature of the ship. The ship is wet and moist when the fires are burning, but this latter circumstance keeps the ship in a positive condition notwithstanding. When the fires are put out, the ship continues wet, and the evaporation goes on, but to a less extent, though sufficient to reduce the electric tension of the ship and everything in it. When the fires were burning, the people in the ship were not exposed to have the electricity of their bodies withdrawn from them, as the ship could yield them a quantity, even though it was continually parting with it, in drying up the water.

It is stated that disease, when it appears in steam-ships, is more severe than in the sailing vessels. In the torrid zone it is found that yellow fever is not produced by the drying process, which takes place at a swamp, as this is comparatively slow, and reduces the electric tension proportionally little. It is near swamps that intermittents and remittents appear, and these are severe just in proportion to the heat of the climate where the swamp is placed. It requires a more hurried evaporating process to produce yellow fever, a more and more effectual and speedy abstraction of vital electricity. Barbadoes was at one time swampy, and had endemic intermittent fever. It was drained, and since that, it is occasionally visited with severe and deadly fevers. Whilst it was swampy the evaporation was slow, and the locality was made slowly negative, and the effect on the body was proportionally mild. When the rains were hurriedly dried up, the locality was speedily made negative, as the evaporation was quick, and the depressing effect was proportionally severe. A damp sailing ship in the torrid zone, with the heat operating upon it causing evaporation, will produce a milder form of disease, than arises in the steam-ship, there being a less amount of alteration of electric tension. The mere sailing ship may represent a swampy neighbourhood, whilst the steam-ship may be said to be in the same position as a region where, after the periodic rains, the sun dries up the water in the most rapid manner. In the steam-ship, when the fires are burning, there is a speedy drying up of the moisture, but if the artificial heat be withdrawn, the sudden cooling causes a more and more severe form of disease, as a consequence of the greater reduction of the electric tension.

The "Eclair" steam-ship has been long known to the profession and public as being notoriously unhealthy. So frequently has disease made its appearance in it that seamen have refused to join it, and hence its name was changed to "Rosamond." But this did not alter the condition of the ship, as its insalubrity continued unabated. The unfortunate peculiarity in this ship may be traced to the same cause which operates injuriously in other ships. Dr. Copland, in his article on Hæmagastric Pestileone, gives an account of the "Eclair." He states, "The 'Eclair' steam-ship left Plymouth on the 2nd of November, 1844, with a crew of 146 officers and men. On the 20th of December, she was at the river Gaboon, on the west coast of Africa, and passed thence westwards and northwards along the coast until she arrived at Sierra Leone on the 23rd. She there took in forty Kroomen and liberated Africans, allowed to assist the crew. She departed from Sierra Leone on the 28th of January, and continued off Sheerboro', watching slave-traders, until the 4th of February. During this time, the vessel could not have approached nearer than three miles to the shore, owing to the shelving nature of the coast; but the boats were sent in, and the men landed frequently, and slept on shore on two or three occasions. Most of the men who had slept on shore were attacked with fever, which appeared to have been of a malignant kind, as nine or ten of those attacked died; but two of the men who were severely seized had not been out of the ship. These cases occurred during the months of April, May, and June, and were said to have been the endemic remittent of the climate; but no details of symptoms are given. When the vessel returned to Sierra Leone, on the 4th of July, the crew was healthy; but from that time until her departure on the 23rd, the men were engaged in cleaning out the hold of the 'Albert' iron steam-ship, and were allowed to go on shore, and several of them slept on shore. Of these, four were attacked on the 19th, 21st, 22nd, and 23rd; one was landed, but the other three were treated on board, and died. . . . . . .

"The 'Albert' was taken in tow by the 'Eclair,' and brought into the Gambia on the 10th of August. After leaving Sierra Leone, three other men were attacked in the end of July, and died: these men had also slept on shore; and a merchant, who embarked on board the 'Albert' at Sierra Leone, was also taken ill in that vessel, and died on the 27th of July. The first three of those attacked in August were on board of the 'Albert' when taken ill. Afterwards, the fever became indiscriminate in its attacks. The 'Eclair' touched at Goree to take in coals, but was not allowed pratique. She went on to Bona Vista, one of the Cape de Verd Islands, where she arrived on the 21st of August, having had, from leaving Sierra Leone, eighteen men attacked by the distemper, and of these, thirteen died, most of them with the black vomit.

"At Bona Vista, the disease continued to spread rapidly amongst the crew, when, permission having been obtained from the Portuguese governor, it was determined to land the crew, sick and well, and purify the vessel. A fort was appropriated for the accommodation of the seamen and sick, and the officers obtained lodgings in the town. Every means were taken to purify the ship by washing and white-washing, fumigation, &c.; all the Kroomen remaining on board, with the exception of six employed in attendance upon the sick. The disease, however, continued to prevail amongst the officers and men on shore, thirty-one men having died between the 21st of August and the 13th of September. Under these circumstances, a consultation was held by three naval surgeons, and upon their report and recommendation, it was determined that the steamer and crew should proceed to England. The ship's company were, in consequence, re-embarked, and sailed on the 13th of September; Captain Estcourt having been taken ill the day before leaving Bona Vista, and died on the 16th. At Bona Vista, the assistant-surgeon, Harke, of the 'Eclair,' died, when Dr. McClure, a naval surgeon, passenger in the 'Growler,' and Mr. Coffy, assistant-surgeon of the 'Growler,' volunteered their services on board; here also seven seamen volunteered from the 'Growler.' Dr. McClure died on the voyage to Madeira, and one of the volunteer seamen was taken ill of the fever, and recovered. Upon the arrival of the steamer at Madeira, the authorities refused permission to communicate with shore, as had been previously done by the French at Goree; but, at this island, Mr. Barnard, a naval surgeon, volunteered his services, and was received on board with two seamen. From the day of her sailing from Madeira, the 21st of September, up to the 30th, seven deaths have taken place from the fever, and eight new cases have occurred.

"On the passage from Bona Vista to England, forty-one were attacked, and twelve died. In the short time of the vessel's remaining at the Motherbank, two men were seized and died. From the time of her being put on quarantine, on her arrival, until the 31st of October, nine new cases occurred, five of which were fatal. The pilot, who was taken on board on the 1st of October, to take her to Standgate Creek, was taken ill on the 7th. An officer was also seized on the same day, and both officer and pilot died in three or four days. The surgeon was taken ill on the 4th of October, and the assistant-surgeon on the 5th; the former died. The illness of the two surgeons occasioned the sending two other medical officers, on the 5th, on board the 'Eclair,' and one of them was attacked on the 11th. After this period, but slight illness occurred, and the disease entirely ceased soon afterwards, owing to the arrangements made under the directions of the quarantine establishment, aided, most probably, by the low range of temperature at this season and in this climate. . . . . .

"In further proof of the above, it may be added, that of the four officers of the 'Growler' steamer sent to survey the purser's stores on board the 'Eclair,' three of them—the lieutenant, purser, and clerk—were attacked in consequence, and several of the crew; 'in all, thirteen cases: and two of the three last cases died at Woolwich with all the symptoms of the disease.'"

In the above account, there is no mention of the age of the ship; but, in the absence of information on that point, it may be presumed that the trip to the coast of Africa was one of its earliest commissions. On this ground, it may be concluded that the ship was perfectly dry and in every respect in good condition when it left on the 2nd of November. The "Eclair" arrived at Sierra Leone without accident in about fifty-one days, and in forty-three additional days left Sheerboro', the crew being all in good health. There is no report of any sickness for thirty days more; making 124 days since the ship left England without any case of sickness on board. About this time, a number of the crew had gone ashore and slept there, and these, almost without exception, took fever, and it was among them alone that there was the mortality. The ship is reported at Sierra Leone, on the 4th of July, all well, so that it had now been at sea about 244 days without any sickness which could be considered as having arisen from the vessel. It is stated that as soon as the crew were engaged to clean out the ship "Albert," the sickness reappeared; but as they remained, sometimes in the ship and sometimes on the shore, during the cleaning of the "Albert," it is not possible to discover whether the cause of the disease in the men had proceeded from the ship or from the shore. The three men who died after leaving Sierra Leone had slept on shore. The merchant who died in the other ship had slept on shore also. After this, it is stated that "the fever became indiscriminate in its attacks." The "Eclair" had been at sea between eight and nine months, and no case of fever could be traced to having had its source in the ship. All that had hitherto died had slept on shore. No mention is made of the condition of the weather, or what sort of accommodation the men had when they were on shore. If it was at the epidemic season, there might be strong reasons for suspecting that the injury to the cases proving fatal was received on shore. Neither is there any mention made of the condition of the ship, whether it was dry, or what amount of water was in the hold. There are strong reasons for suspecting that from the time the ship put to sea the hold may have been becoming more and more foul. In the management of a steam-engine, there are emissions of steam, causing the place to have a moist air, and a probable escape of water from the service-pipe, unless great care is exercised to prevent it. The accumulation of water in the hold would be equivalent to a swamp on land, and the heat of the sun may be represented by the heat of the fire and boilers. So long as the fires continued to burn, the ship would be kept at a high temperature, notwithstanding the depressing influence of the evaporation; and the ship might be kept in a positive electric condition if the fires were constantly burning; but when the fires are withdrawn, and the ship is exclusively under canvas, then, in hot climates, the water in the hold would continue to evaporate by the height of the general temperature; and in the absence of the compensating heat of the furnace, a low state of electric tension would be induced in the ship, which would exact vital electricity from the people in it, and cause diseases which arise from a weak condition of the nervous powers. Dr. Copland mentions in his note that in the sick on board the "Eclair," when on the coast of Africa, the urine was suppressed. The consequence of the suppression of this complicated and irritating excretion would cause its constituents to remain in the blood. It is easy to conceive that the retention of these bodies, which ought to have been thrown out, will cause a large amount of mischief through the body, but especially in the capillary vessels. The corpuscles of the blood will be altered, both in their condition and composition, causing obstruction at one place and rupture at another, and pain, less or more, in every part of the body.

There is a question of no little moment involved in the solution of the problem which it is the object of this inquiry to solve, and which will have some bearing on it, viz.:—the laws of quarantine. It is a most intolerable grievance for the crew of a ship to be detained for weeks outside the harbour, in sight of their friends whom they have not seen for months, but unable to exchange with them the sentiments which must be throbbing in their hearts, and though at the very threshold of home, unable to enter, merely for laws made on uncertain and very unsatisfactory data. When a ship is known to be pestiferous, known to have the virus in itself, is it not cruel to immolate the poor men on the shrine of suspected contagion, when they could be delivered without fear? There is little doubt but that the officers sent to survey the purser's stores might have done their service and escaped being affected, if they had been exposed only whilst at duty to the pestiferous emanations of this ill-conditioned ship, as the abstracting influences would not have had time enough to act injuriously.

With a view to drive out the infectious agent, the washings and fumigations were instituted, but unavailingly. According to the principles here advanced, the process would aggravate the evil, as it would more thoroughly wet the ship and give rise to more active evaporation.

We find the "Eclair" under the name "Rosamond," in the summer of 1851, in the West Indies. The weather was unfavourable, an element to be taken into account when judging of the ship. Dr. Watson, writing in the *Monthly Journal of Medical Science*, for November, 1852, gives the following account of her:—

"The 'Rosamond' arrived here from Europe in December, 1851, and afterwards made several trips to the Spanish Main, and among the islands, during which her people enjoyed good health. There were a few cases of mild seasoning fever, such as most new crews experience, on first coming to the West Indies; but the general sanatory state on board was quite satisfactory. On the 4th June she took her departure from Port Royal, and anchored at Grey Town, Nicaragua, on the 9th of the same month, with no disease then on board. The anchorage of Port Royal not being productive of marsh remittent fever, terminating in ague, there can be no doubt that the serious disease which soon after manifested itself in the 'Rosamond' had its origin in the harbour of Grey Town.

"That harbour is a circular basin, at the mouth of the river St. Juan, land-locked, and surrounded by a low, swampy country, containing many lagoons, and covered with thick forests, and a dense undergrowth of tropical vegetation. The river opens into the basin by several mouths, with low, alluvial sands between them; its bottom is a thick mud, and the beach is composed of a dirty, muddy sand, with a nearly impenetrable *bush* towards the land. The vessel lay near the centre of the harbour, which is not less than half a mile from the shore, from the 9th June till the 4th July, when, having in the interval had thirty severe cases of fever, she proceeded to the Island of St. Andrews, which is 150 miles to windward, far removed from the coast, and esteemed very healthy. She returned to Grey Town on the 11th July, and the day following, in consequence of the continued and increasing sickly condition of her crew, she put to sea, and made the best of her way to Jamaica, where she arrived and disembarked her sick at this hospital on the 17th July.

"While the 'Rosamond' remained at Grey Town it rained almost incessantly the greater part of every day. The awnings were sloped to protect the people from the rain, but the protection so afforded was only partial, and the interior of the vessel, as well as the clothing and the bedding, was necessarily very damp. The temperature was comparatively low, being usually from 76° to 78° Fah. in the shade. I believe it has been the practice to permit the crews of ships stationed at Grey Town to fish in the river with the seine. The 'Rosamond's' people received this indulgence, and a portion of them used to fish in the river, when the weather permitted, from four to seven o'clock in the morning. The amusement was, of course, attended with much bodily exertion and complete exposure to wet, while it continued, at least as far upwards as the waist."

The cause, which occasionally operates so malignantly in this ship, does not seem to remain permanently in her, as in the present instance, it appears from the above extract, that she had been sailing in the torrid zone for six or seven months without having any sickness on board during the whole of that time. Very soon, however, after the ship arrived at Grey Town, the crew became ill, and before she left that town, there were thirty-seven cases of illness in eleven days. Now, what was the cause of this sudden illness of the crew? It has been stated by the reviewer of Dr. Macculloch's work on Malaria, that ships have been anchored half a cable's length from what was considered a malarious shore, where people were affected with intermittent and remittent fever, whilst the seamen in the ships continued well. Now, in the present instance, is it likely that the crew of the "Rosamond" would be affected by influences from the shore? The following is the passage from the above-mentioned review, and which, though quoted formerly, we take the liberty of again quoting:—"How does it comport with the well-known fact, that our ships, moored close along the banks of the Scheldt, entirely escaped the fever, while the soldiers quartered within half a cable's length of them, were affected with the epidemic?" The same has been observed in hundreds of other places.

There are circumstances to be taken into account, which are unconnected with the ship, as reported in the above extract. Sixty-five per cent. of the men who had gone to fish are represented as having become ill. The fishing in the water, and the getting wet, were all independent of the ship. There is little doubt but that the unwholesome condition of the ship, and the concomitant fishing, were the injurious causes. The remaining in the water so long, and the being rained upon whilst fishing, had a powerful effect in reducing the electric tension of the human body, and consequently lessening the nervous powers. The abstracting power of the water of the river, operating upon the extremities and lower part of the body, was one means by which the electricity was abstracted from the body, and the wetting of the upper half of the body and consequent evaporation of the rain, would abstract electricity powerfully so long as the garments were wet. The "much bodily exertion" would also have a depressing effect, as it would, to a certain degree, exhaust the nervous power. Had the fishers gone to a thoroughly healthy ship, in all probability the illness would have been less severe, whilst those of the crew who remained in the ship might have escaped disease altogether. With the interior of the ship wet, and the very clothes and bedding damp, how was it possible that health could be preserved in a ship with such disadvantages? The water in the ship, and on the clothes, would require to be all raised by evaporation. The heat of the climate would help to accomplish this; but the electricity of the crew would be abstracted to assist in the operation.

The same vessel was found in the Black Sea fleet in 1855. The following fact is stated by Dr. Pinkerton in a report on the Crimean Campaign. "A curious form of fever broke out on board the 'Rosamond' (the yellow fever stricken 'Eclair') in the Black Sea, among the men employed clearing out her hold. It was unlike all the other fevers seen in the fleet, and it was confined to the men who were subjected to the air from the hold, which had long lain foul." The circumstance of the hold having "long lain foul," shows that it was characteristic of the vessel to have the hold in this condition, and it could not be foul without containing water also, and thus providing for evaporation. But in the cleaning operation above reported, there may have been certain gaseous emanations which would powerfully and injuriously impress the vital powers.

The character of foulness in the holds of the ships in the public service, was much more applicable some time ago than it is at present. The reviewer of Dr. Wilson's *Memoirs of the West Indian Fever* states, that "It was at one time imagined, and Bancroft laboured hard to establish the fact, that the moisture which is always present in the holds of ships, and mixed with vegetable matter, undergoing, in this climate, rapid decomposition, is quite equivalent to a marsh on shore. Some plausibility for the view might be derived from the gravel and sand which was then in use for ballast. Since the introduction of pig-iron bars, however, for this purpose, and the use of iron tanks for the water, no argument of any strength whatever can be derived from this source. The hold of a ship, especially in the public service, is as clean and dry as a floor. Yet yellow fever, with its usual malignity, has not been wanting."*

The condition of the "Eclair," and of another ship, the "Dreadnought," mentioned in Dr. Pinkerton's report, with foul holds, is an instructive commentary on the statement made in 1827, that "the hold of a ship, especially in the public service, is as clean and dry as a floor." There is another source, whence may spring diseases amongst a crew, independently altogether of the ship and anything connected with it. So long as the ship cruises about, "though along an unhealthy coast," the crew are not unfavourably operated upon. But when they cast anchor and remain for some time, then they often become affected. The men are indulged, not as those of the "Rosamond," at Grey Town, by being allowed to go down to the river to fish, but by being permitted, and it as dangerous an indulgence, to go on shore and trade with the people, and remain

* Ed. Med. Journal for April, 1858.

on shore all night, drinking and practising other debaucheries. Then there may be disease among the crew independently of the ship. The being on shore during sunshine, is not attended with the same hazard as during the night, since the heat of the sun will then preserve the region in a positive condition, notwithstanding the evaporation. At night, the effects of evaporation, especially if it be immediately after the rainy season, will be very prejudicial to the health of those exposed to it.

The exhausting effect of drunkenness, and other forms of dissipation, would reduce the nervous force to a large extent, and the abstracting power of the evaporation, by causing the locality to be in a negative state, would abstract the vital electricity of that portion of the crew exposed to it, and cause them to be less positive, less so than is consistent with healthy action; and hence fevers and other diseases which depend on reduced nervous powers.

A much larger number of facts might be adduced, to show that disease on board ship at sea has its source in the ship itself; and, unless on board steamships in warm climates, there is never disease of the severest type, such as plague, yellow fever, or cholera, till the crew have had communication with the land.

CHAPTER VIII.

EXAMPLES OF INSALUBRITY, INDEPENDENT OF EVAPORATION.

As an objection to the general application of these principles, it may be held that, in some districts, epidemic diseases prevail to a large extent, and cannot depend on the effects of evaporation, there being no vapour present. In such circumstances, there may be in operation some influences causing epidemic diseases which depend on the disturbance of the equilibrium of the electric tension of the earth, where no conducting influences on the surface are apparent; as must have happened in Glasgow and Paris, as cited above, when cholera last prevailed. The numerous and occult variations which are continually going on in the great terrestrial currents, as indicated by the compass of the mariner, show that operations of the most extensive nature, caused by this powerful element, may be going on in the interior of the earth, affecting the surface and disturbing the equilibrium there, causing low tension, and producing irregularities in those situations which may be thus acted on.

As an example of the irregularity and inequality of electric tension, a curious account of fever that is endemical on the hills of the Southern Peninsula of India may be cited. The communication is made by

Dr. Heyne, in the tenth number of the *Madras Medical Journal.* He states, "that the hills where the fever is found to prevail, at the first sight appear harmless. They contain, besides quartz, felspar, and mica, a great proportion of ferruginous hornblende, which, by its disintegration, or separation from the rock, becomes highly magnetic, and in which, I suppose, the cause resides which produces the fever, besides a great train of other disorders." "A most remarkable instance illustrative of these facts, and my deductions from them, I found at Zupetoor, which lies in a valley, close to a large table-land, the rock of which is sandstone. I asked there a respectable native, whether any such disorders are frequent, and received for an answer, 'No, thank God! not within ten miles of this place; but at Tavachymalle, a hilly part, where no man can live two days without getting it.' To this place a Peon was dispatched, with the simple request to bring two or three stones from the rock of the hill, and some sand as may be found on the road. The man returned, and brought pieces of rock composed of felspar, quartz, and plenty of ferruginous hornblende, and the sand of the rock consisted entirely of magnetic sand, and particles of felspar. In that range of those hills, the rocks vary much in their formation, and wherever the iron granite occurs, the malignant peculiarity is uniformly connected with them. Hornblende in trap contains nearly as much iron as that of the granite; the iron, also, in other minerals, as in the magnetic ore, and the carbonated iron ore of that country, possesses as much magnetism in its active state, yet do they not prove themselves in the least hurtful to the constitution."

Dr. Heyne very correctly, in the opinion of the author, attributes the insalubrity of these iron-granite hills to the magnetic condition of the rocks composing them, but does not mention the manner in which the magnetism is supposed to act so prejudicially on the human body. The readiness with which the iron-granite becomes disintegrated depends on a want of latent electricity, the binding principle in all matter; and in this way, cohesion is disturbed, and the atoms fall asunder. According to the principles here advanced, the unfavourable agency may be produced in the following manner:—The diminished amount of latent electricity in these magnetic minerals may cause them to have a large capacity for absorbing it from every object that may come in contact with them. The animal bodies must be always positive, in consequence of continually acquiring latent electricity from the air during respiration, and from the food during digestion, and will readily give off their electricity; and if such a quantity be withdrawn as will leave less behind than is necessary for supplying power for supporting the vital operations, there will be produced diseases depending on the imperfectly performed assimilation, secretion, and excretion. There are here none of the usual conditions for creating malarious emanations—neither decomposing vegetable nor animal matter; and moisture seems to protect rather than be injurious, as, whilst the rain is falling, it is observed that the malignant peculiarity is arrested. The ameliorating influence which rain may exercise on the insalubrity of this region may be produced in the following manner:—The electric fluid which is drained from the earth by evaporation will be retained in the clouds, and, if not given off in such a concentrated condition as to come forth in the condition of lightning, it will come down to the earth diffused amongst the rain; and this rocky region, which is before in a highly negative condition, will, by the supply thus communicated, become converted into much more positive circumstances, till the electricity is again drawn off by renewed evaporation.

In the review of Dr. Wilson's *Memoirs of West Indian Fever*, already quoted, there are notices of various places which have a febriferous notoriety, and of which some of the mountains present as little vegetable life as those in Southern India already referred to. The geologic formation, however, is very different. The rocks on the hills of Tavachymalle are ferruginous, and magnetic in their composition; those pointed out in Dr. Wilson's *Memoirs* are principally calcareous or coralline in their structure.

One object of Dr. Wilson's *Memoir* is to trace a connexion between ligneous decomposition and the cause of the endemic fevers which prevail in certain barren regions of the West Indies. The reviewer says: * "The islands of the Caribbean Archipelago consist chiefly of calcareous matter, of what the geological writers term the secondary formation, and sometimes of entire masses of coral. The texture of this is so loose, porous, and covered with crevices, as to form at all times a never-failing receptacle for every species of decayed and decaying wood, leaves, &c., which Dr. Wilson thinks there is good reason for believing the immediate source of

* Ed. Med. and Surg. Journal for 1828.

the peculiar fever which has been so long indigenous in this part of the world. Wherever the calcareous subsoil is scantily covered with earth and herbage, fever is frequent and severe; and the thinness or absence of this covering appears to operate in allowing the woody matters to run to decay in a situation in which the gaseous products of decomposition are incessantly escaping, to affect the frames of those persons who reside in their vicinity.

"This view he illustrates, in the first place, by reference to Jamaica, great part of which is a calcareous crust, destitute of superincumbent soil, in many places in which fever is always most frequent and severe. The vicinity of Rock Fort, for example, three miles east of Kingston, the basis of which is coral, and the mountain behind a naked calcareous mass, has been at all times so fatal to our troops, that whole garrisons have been successively destroyed. To the men of the naval force in this position, it has been not less pernicious; and to prevent the mortality invariably occasioned by watering parties, the use of floating tanks, wrought by negroes, has been found indispensable. Stoney Hill, already mentioned as peculiarly fatal to the 77th regiment, consists of a great mass of calcareous rock, intersected by deep fissures, and split in many places into large fragments piled on each other, and crumbling into powder; situations very favourable, Dr. Wilson concludes, for the reception and decay of woody matters."

Dr. Wilson rests his hypothesis on very gratuitous grounds. There are decayed and decaying wood and vegetable matter all over the world, and in much greater abundance, and in much better circumstances for decomposition, than in the crevices of dry rocks. It is found, in all other places where diseases prevail, that moisture is indispensable for decomposition, and in these dry rocks there is no chance of water being left in contact with the ligneous deposits for any length of time. It would appear that this locality cannot sustain vegetable life. Indeed, on a dry rock how could nourishment be supplied? The want of food may have been but one reason for the destitution of vegetable life. There may be in the rocks a power which withdraws from them that element, without which vegetables cannot appropriate the food to sustain them, though it be presented to them. That element is electricity. The crumbling condition of the rocks, as in those mentioned above, may arise from a power which divests the atoms of which the rock is composed of the latent electricity which binds them together. There may be a great lack of this element, causing a highly negative condition of the whole rocky region. If in the rocks there exists a powerfully abstracting element, withdrawing the living principle from vegetable existence, it is not to be expected that the continuous operation of this power on animal life can fail to be prejudicial, and hence the readiness with which fever seized on those who remained in contact with them for any length of time. In consequence of the calcareous formation of the rocks in the West Indies, there cannot be the magnetic properties which belong to the ferruginous rocks of the East; but if the analogy fail in respect to the magnetic peculiarity, it holds good in other respects. The disintegration is the same in the one as in the other, and they also hold the insalubrity in common.

Stoney Hill is particularly characterised by the breaking up of the rocks into large fragments, as well as by their crumbling into powder; and on the principles here assumed, they must be highly negative in point of electric tension. Then, as all animals are positive, they will give off their electricity to the negative rocks; for as water finds its level, so does electricity find its equilibrium. When a body in a positive condition is brought into contact with one that is negative, the positive body will give off as much of its electricity as will make the negative body equal with it. In the case of the 77th regiment, which was nearly destroyed, the soldiers when sent there were in ordinary good health, and consequently highly positive. As soon, however, as they came to this rock, the equalizing of the equilibrium between the positive soldiers and the negative rock began. Those of the soldiers who possessed the least amount of nervous power would be the first to sink under the abstracting process, and so amongst the rest in regular succession, one after the other, or several together, till the strongest was brought down. This loss of nervous or electric power would not be so great as all at once to mar the vital operations; but the continued or repeated abstractions, by this equalizing process, would ultimately reduce the nervous power so as to render it unfit to continue those offices in the animal economy, which are essential to the integrity of healthy action. The soldiers for a while would feel little alteration of their condition—little diminution of their strength; but a persisting continuation of the abstracting agency of the electro-negative rock on which they were placed would, in process of time, cause those changes in the blood, and consequent vascular and organic lesions, which are found in pestilential diseases. This rock seems to have been so injurious as to prevent seamen remaining on it, even for the short time occupied in procuring water.

Port Haldane, at Port Maria, is another military port which was found to be febriferous. An account is given of it in the same review of Dr. Wilson's work:—"Port Haldane, at Port Maria, which is an elevated mass of limestone, washed on three sides by the sea, might be thought to be the most healthy station in the West Indies. It is, nevertheless, the source of fever so deadly, that for some years it has not been garrisoned. In November, 1824, when, by the urgent entreaty of the local authorities, in apprehension of insurrection among the slaves, a detachment of the 50th regiment was stationed in the barracks, the appearance of fever was so early, and its havoc so great, that it was found necessary in six weeks to remove the detachment, after losing one-third of its number, and with nearly the whole remainder labouring under the disease. Dr. Wilson thinks there is good reason for regarding the mangroves, which cover the banks of two streams which fall into the bay, to be the material source of this epidemic sickliness. At Port Antonio, distinguished for similar geological relations, the port and barracks have been abandoned for the same reason. Port Royal, the extreme sickliness of which is too well known even in this country, is a narrow coralline promontory, covered with sands and gravel only.

the public buildings, and the dwellings of the inhabitants."

This port is so unhealthy, that it is not surprising that it was abandoned altogether. There seem to have been two sources whence may have arisen the deadly insalubrity of this situation. There is, first, the rock itself, of the same geological formation as the other pestiferous places around; and there are the mangrove plants lining the streams which fall into the bay, near the military port. These plants act like a sponge, imbibing a large quantity of water when the sea overflows them. When it recedes, the large quantity of water in these plants is exposed to the sun, which causes a most copious evaporation, withdrawing electricity from a place already very destitute of it, and producing a highly negative state of the locality. The rock on which the barracks were built is presumed to have been highly negative, from its being of the same calcareous character as the others. It is not, indeed, said that the rock was broken up, and crumbling into powder, as if it had lost the latent electricity by which its atoms are kept together. It is said that the detachment of a regiment remained six weeks in the barracks, and in that time lost a third part of its number; and not only did it lose this large portion, but amongst those who were allowed to leave with their lives, nearly all were labouring under disease. The reason why those men who escaped with their lives were labouring under disease, may be the following:—The same detracting influences were operating upon all alike. There was the same abstraction of nervous power from each. Those with the least amount of nervous vigour would be the first to succumb, as, by the failure of the vital operations, the excretions would be retained in the circulating fluid, and the blood would be vitiated, and from the consequent capillary changes in all the organs of the body would arise the fatal issue. All those who escaped with their lives would have their nervous forces so much exhausted that the operations of digestion, assimilation, secretion, and excretion, would be very much marred, and the blood less or more deteriorated, but still not so much so as to be inconsistent with a sort of lame life. And in proportion to the amount of change in the blood, so would be the prospect of recovery. The powers of the system would be fully re-established, when the men were placed in a favourable situation, only by effecting the expulsion from the blood of those bodies which were retained by a previous inability to throw them out, and thereby recover sound health, provided no serious organic change had been induced. Dr. Wilson further mentions a number of places with the same kind of rocks, and the same insalubrity. The author quotes once more from the review:—

"He proceeds to establish, in a very clear and interesting manner, the same connexion between the loose perforation or fissured calcareous formations, and the prevalence and fatality of yellow fever, at Port of Spain, in the island of Trinidad; at Fort Louis, in that of Martinique; at Point-à-Pitre, Fort Louis, and Fort Fleur de Pays, in Guadaloupe; Port-au-Prince and Fort Bizoton, St. Domingo; and at Bridgetown, in Barbadoes. Even Nassau, in New Providence, though situate to the north of the northern tropic, and therefore enjoying the alternation of season, yet, as presenting, especially at Fort

Charlotte, a dry limestone flat, is consigned to the same class of febriferous situations."

It would have been more satisfactory, if Dr. Wilson had stated whether the loose perforated condition of the rocks and the insalubrity were constant, whether there were not places with the same kind of rocks, and these in the same broken condition, but yet found perfectly salubrious. If the broken-down and crumbling condition of the rocks, and the prevalence of disease be uniform, then the connexion is established. But if it be found that in the same vicinity, and in the same calcareous formation, the same crumbling and breaking down of the rocks are associated with the most perfect healthfulness, even yielding specimens of human longevity, there are grounds for questioning the truth of the premises founded on such data:

When it is stated by competent authorities that, in many positions on the earth, a low condition of electric tension is found to be concomitant with pestilential disease, it may be presumed that there is a connexion between the low state of electric tension and the cause of disease in most parts of the earth, although the fact is not recognised by ordinary observers. In those reports which emanate from medical men practising in the torrid zone, there are, so far as is known to the writer, no accounts of observations on the subject of electric tension; and observations on this subject, in other parts of the world, have been made more by chance than from any set purpose. In a review of a report on Asiatic Cholera, in the *Edinburgh Medical and Surgical Journal* for 1825, the following allusion is made to a theory of Mr. Orton's:—"The farther part of Mr. Orton's theory, which ascribes the diminution of nervous influence to a deficiency of electricity, is either too ridiculous to be made the subject of remark, or too fine to be appreciated." Mr. Orton is not represented as stating what connexion there is between diminution of nervous influence and deficiency of electricity. It was probably on consideration of the vagueness of the statement which induced the reviewer to consider Mr. Orton's theory too fine to be appreciated. If Dr. Wilson had examined the electric condition of those calcareous rocks which had the crumbling and insalubrious peculiarity, and had found that the insalubrious character was uniformly associated with them, the necessity for taking any theory for granted would have been removed.

CHAPTER IX.

THAT FACILITIES FOR EVAPORATION ARE GREATEST IN DEPENDING POSITIONS, HAS GIVEN RISE TO THE IDEA THAT MIASM IS PONDEROUS.

Some reference has already been made to malaria, as having a property common to almost all bodies, viz., ponderousness, or a certain specific gravity. This impression has arisen from the circumstance, that in unhealthy regions the greatest amount of injury is inflicted on those who are placed in low levels, whilst those who are elevated near the same situation receive little or no harm. It is on this ground that the property of ponderousness has been attributed to this imaginary element. We can take under our cognizance all other ponderable bodies, yet here is an element invested with a property of matter, before it is determined whether it has any existence. Heat, light, and electricity, although mere manifestations of the same element, can each be recognised by certain special physical properties which it possesses. We can feel the warmth of the fire, and see whence its heat proceeds. We can see the thunderbolt and the light of the sun; and these are designated imponderable bodies. Yet here is an imaginary element invested with a property that keeps it near the ground, and near our grasp, but which has hitherto given no reply to many interrogations.

By the principles here advocated, a reason can be assigned for the unhealthiness of a given locality, adequate to account for its insalubrity, on other and more rational grounds than supposing the existence of malaria.

The impression that ponderousness is one of the properties of malaria has arisen, as already stated, from finding that in low situations, and on ground-floors of houses, there is a marked increase of insalubrity, as contrasted with elevated situations in their immediate neighbourhood. This impression is strengthened by the uniformity with which this fact is recognised. Dr. Watson mentions several facts, which demonstrate that the nearer the ground, the greater is the unhealthiness.

" Malaria *loves the ground.** It tends downwards. Whether this results from its specific gravity, or from its adhering to the moisture suspended in the lower strata of the atmosphere, or for some peculiar attraction for the earth's surface, I cannot tell you. There is reason to suppose that the poison combines, somehow, or becomes entangled with fog ; and fogs usually brood and settle at night, especially upon the surface. This may be one reason why *lying down* to sleep in the open air at night is so very perilous. The lower rooms of the same house may contain the noxious effluvia, while the upper are free. 'In all malarious seasons and countries,' says Dr. Ferguson, 'the inhabitants of ground-floors are uniformly affected in a greater proportion than those of the upper stories. According to official returns, during the last sickly season, at Barbadoes, the proportion of those taken ill with fever in the lower

* Watson's Prac. of Med. vol. i. p. 729.

apartments of the barracks exceeded that of the upper by one-third, throughout the whole course of the epidemic. At the same time it was observed that the deep ditches of the forts, even though they contained no water—and still more, the deep ravines of rivers and water-courses—abounded with the malarious poison.' Dr. Hunter, in his work on the Diseases of the Army in Jamaica, says, 'The barracks of Spanish Town consist of two floors, the first upon the ground, the second on the first. The difference in the health of the men on the two floors was so striking, as to engage the attention of the Assembly of the island; and, upon investigation, it appeared that *three* were taken ill on the ground floor, for *one* on the other. The ground floor was not, therefore, used as a barrack afterwards.' Mr. Ralph, in a table printed as an appendix to a paper of Dr. Ferguson's in the eighth volume of the *Medico-Chirurgical Transactions*, states the result of an inquiry into the comparative healthfulness of the upper and lower apartments of barracks in Barbadoes to have been, that the individuals residing in the lower apartments were attacked in the proportion of two to one of those living in the upper; and, with certain apparent exceptions, which I shall notice presently, experience is uniformly in favour of the proposition, that the poison is most prevalent and destructive near the surface of the earth, and does not rise high into the atmosphere."

Data resting on unsatisfactory grounds tend always to give rise to unsatisfactory conclusions. In the absence of everything certain, it is perfectly rational to speculate on the phenomena which present themselves most conspicuously to our observation. In almost all the disease-begetting places in the torrid zone, there is moisture in the air where there is water in the soil. At one time of the twenty-four hours there is a sufficient reduction of temperature in the air to produce that partial condensation of the moisture, called mist; and when this mist occupies a certain locality, which is notorious for producing disease, there are grounds for supposing that the mist and the disease have some connexion. The mist is evidence that heat has operated on a moist soil; and the poison may be considered in combination with the mist, in so far as it contains the electricity which has been taken from the soil to cause the evaporation of which the mist is the result; and the electricity being drawn in this way from the ground, will place it in a much more negative condition than before the evaporation. The more thoroughly negative the ground is found to be, the more hazardous is it for animals to remain in contact with it. It is at night, in the absence of the sun, that this takes place—that the earth becomes most effectually negative. The continuation of the evaporation after sunset draws from the earth the electricity which it has absorbed whilst the rays of the sun were shining on it, and in this manner the negative condition of the soil is produced; and this negative condition is intensified, till the sun returns to heat the soil. The same principles may be applied to account for the greater insalubrity of the ground floors of barracks, as compared with the upper floors, in warm countries. The lower floors in these buildings may be made of stone, on account of its cooling properties. If this is the case, the floors will partake of the same electric condition as the soil around, since there is no non-conducting property in the stone to prevent the operation of the law of equilibrium, by which the electric condition of the stone floors will be assimilated to that of the ground outside. In bed, there will be an approach to insulation. If the frame is made of wood, and the blankets are composed of wool, this will still further accomplish the object. The position of those on the higher floors was much better for insulation than that of those living on the ground floors. They of necessity had wooden floors, and in their beds, under the non-conducting woollen blankets, their insulation would be pretty perfectly secured; and had they been confined to their rooms, and kept off from the walls day and night, they might, according to the principles here advocated, have escaped the disease altogether. But soldiers are not easily restrained from exposing themselves to the night-air out of doors, and when out, it might be with the additional hazard of being in a state of drunkenness. The reason that contact with the walls is more dangerous than being placed in the centre of the room is, that the walls, being made of stone, are good conductors of electricity, and, by being rested on the ground, which is in a low electric condition, they are kept in a similar negative state. Then, if bodies in a positive condition remain for a sufficient length of time in contact with these walls, such as when one looks out at a window, an abstraction of vital electricity will take place, to the greater or less injury of the person thus engaged. The difference of the effects of this malign influence in these barracks is strikingly great, between the people on the ground floors and those on the floors above. Dr. Ferguson estimated the mortality of those in the rooms on the ground floors to be one-third greater than those in the rooms on the upper floors. Mr. Ralph estimated them as two to one, and Mr. Hunter as three to one. The disparity between the estimates of these different observers may have arisen from Dr. Ferguson having made his statement from memory. The statements of Mr. Hunter have the greater claim on our confidence, as they are apparently official. The dried ditches, and ravines of rivers and water-courses, would be perfectly innocuous, if they were completely dry; but it is that after all the flowing and standing water has disappeared, their wet bottoms are exposed to the burning sun, which causes a copious evaporation, and this abstracts the electricity, and produces a negative state of the locality.

Dr. Watson mentions, also, that malaria is movable by the wind. As an illustration of this, he gives an account of an unhealthy situation in the West Indies, produced after this manner: *—" The miasmata may roll up, and hang accumulated upon the side of a hill, towards which a current of air sets steadily from or across a neighbouring marsh. Nay, the poison may thus be blown *over* a hill, and deposited on the other side of it. In this way, I presume, are to be explained the following curious facts related in Dr. Ferguson's paper:—

" 'The beautiful port of Prince Rupert's, in the island of Dominica, is a peninsula, which comprehends two hills of a remarkable form, joined to the mainland by a flat and very marshy square isthmus, *to windward*, of about three-quarters of a mile in

* Watson's Prac. of Phys. vol. i. p. 731.

extent. The two hills jut right out on the same line to the sea, by which they are on three sides encompassed. The inner hill, of a slender pyramidal form rises from a narrow base nearly perpendicular above and across the mark, from sea to sea, so as completely to shut it out from the port. The outer hill is a round-backed bluff promontory, which breaks off abruptly in the manner of a precipice above the sea. Between the hills runs a very narrow, clean valley, where all the establishments of the garrison were originally placed, the whole space within the peninsula being the driest, the cleanest, and the healthiest surface conceivable. It was speedily found that the barracks in the valley were very unhealthy, and to remedy this fault, advantage was taken of a recess or platform near the top of the inner hill, to construct a barrack which was completely concealed by the crest of the hill from the view of the marsh on the outside, and at least 300 feet above it; but it proved to be pestiferous beyond belief. In fact, no white man could possibly live on it, and it was obliged to be abandoned. At the time this was going on, it was discovered that a quarter which had been built on the outer hill, on nearly the same line of elevation, and exactly 500 yards further removed from the swamp, was perfectly healthy, not a single case of fever having occurred in it from the time it was built.' "

The difficulty can be explained very satisfactorily, as the phenomena appear to be exactly the same as those which take place in those regions which are visited by the Sirocco winds. These winds continue only for a limited time, and the effects are merely transitory on those places which are affected by them. But if they were to blow continuously, these places would be as uninhabitable as the situation described above. The wind from the marsh, blowing steadily on the little hill nearest it, will be loaded with the moisture exhaled from the marsh. It will roll not only on to the hill, but will roll over it also, and moisten the side of the hill farthest from the marsh, thus causing the insalubrity both of the station on this side of the hill and of that in the valley. But it is unlikely that the moist wind will be wafted up the side of the outer hills, as the currents of air, passing along the valley between the hills, will remove the moist air, and prevent its ascent on the outer hill, and the air being dry on this hill, will cause the station on it to be healthy.

Dr. Copland, under the conviction that malaria is of greater specific gravity than common air, recommends* that "buildings, either near or to leeward of any source of malaria, or standing on a deep, moist, or argillaceous soil, should be very high; the ground-floor should be left unoccupied and be open on every side to permit complete perflation; and that side ought to be always shut on which the prevailing night or land winds blow, or towards the place from which unhealthy exhalations proceed. The inhabitants should also keep near the tops of the houses, where, if high built, they will generally be placed above the concentrated vapour and miasma, and in great measure beyond their influence: for, although gentle acclivities or hills in the vicinity will often attract malaria, or be swept by currents of air conveying it, yet precipitous elevations, and

* Copland's Dict. Art. Endemic Influences.

high houses, even near its sources, will frequently escape; as, from its specific gravity, it is confined chiefly near the surface of the earth."

The higher the house in any damp region, the better secured will the people living in them be against the malign influences which surround them. The people occupying the highest part of the house, will be more effectually insulated than all those who live below them, as their floors must of necessity be of wood, and the non-conducting property of this material prevents the radiation from their bodies of electro-nervous power. On the contrary, the people living in the under floors are in much less favourable circumstances, especially if the floor is made of stone, or any similar good conducting material. The stone must be in close connexion with the earth, and partake less or more of all the electric variations to which the ground outside is exposed. There will be the exception, in favour of the floors inside, that the fluctuations will not be so great. Outside, whilst the sun shines, the ground will be much more positive; and in the evening, when the sun is withdrawn, the ground will be much more negative than the stone floors inside. But contrasted with the floors above, the floors on the ground are much more negative at all times, and hence liable to abstract nervous power from those who live on them. Whilst the sun shines during the day, the ground outside is highly positive, and at this time, the people occupying the upper floors may go out with impunity. It is to be apprehended that all of those living in very high floors, who are seized with endemic diseases, must have been exposed to the powerful abstracting influences of the earth when the sun is withdrawn, as, so long as they remain in their houses, they will be exempted from the lowering influence of the negative surface.

In illustration of the beneficial effects of seclusion in preventing the contagion of plague, Dr. Hennen mentions the following facts, which would lead an advocate of malaria, from the circumstance of position, to believe that the mischievous agency which produced plague had a greater specific gravity than common air. He says :—

"I shall now give an instance of the complete immunity afforded by separation where the distance between the infected and the sound was reduced to a few feet, and when the contagion was literally at their very doors. I have already observed that the lower parts of the houses of Valetta are generally occupied as shops, stores, &c., or places of residence for the poorer classes of inhabitants. In the lower part of the hospital of one of the regiments quartered in Valetta during the plague, there resided no less than seven distinct families, in an equal number of separate habitations. The plague raged among these unfortunate people to such an extent, that four families were totally cut off, and of the remainder little more than a fourth escaped with life: the plague raged in every corner of these dwellings, and yet the hospital, which was situated on the upper floor, but whose inmates were kept under the strictest control, escaped all contamination whatever. The heated air and exhalation from the habitations below were in no way guarded against, but had unimpeded access to the windows of the upper apartments, towards which they must naturally have ascended at all times from their greater levity, and into some of which every wind that blew must have impelled them in a state of great concentration. In front of the hospital, it is true, there is a small square or open space, and on one side runs a street (Strada Ponente) of nearly the ordinary breadth; but in the rear it joins a large mass of buildings, and on the western face there is a narrow blind alley only ten feet wide, into which the doors of all the contaminated houses opened, and as these doors were the only means of communication with the external atmosphere, the pent-up space must have been continually filled with the accumulated exhalations from the diseased. This was not a solitary instance of the residents on one floor of a house enjoying the reward of proper precautions, while their negligent neighbours above, below, and around them, were falling victims to the plague, but it is rendered remarkable when we recollect how susceptible to all impressions from atmospheric influence, and from disease of every description, the residents of an hospital usually are, under even the ordinary circumstances of military practice."

The rigid observance of seclusion on the upper floors of a building, may secure the immunity of the inmates on the principles here advocated, irrespective altogether of any contagious principle, or the action of malaria. Where could malaria be found in a more active form than in the concentrated emanations from a confined chamber, the scene of the diseased and dying victims of this pestiferous disease? Although these emanations rose up around, and came in at the windows where the ordinary sick inmates of an hospital are confined, yet none were affected. The exhalations from the lungs of the plague-stricken patient would be inhaled by the squalid inmates of the hospital above, yet no injurious result is said to have followed. The favourable condition of the occupants of the hospital arose as much from their insulation as from their seclusion. The insulation was effected by their being above, and on a timber floor, which is a bad conductor of electricity, and the people resting on it would be kept in a positive condition. The seclusion would prevent the inmates of the hospital from being out of doors and exposed to the negative earth at a time when there was the greatest inequality between the electric condition of the person and the soil on which he was placed; the former being highly positive, and the latter highly negative. When adverting to the negligence of the neighbours, and referring to them falling from plague above, below, and around them, it is not specified whether the above is a floor above, or a higher or lower part of the town. But, if care was not taken to keep within doors after nightfall, the insulation above would not protect them from the injurious influences operating on them, and which are caused by the evaporating operations in the open air when the sun has withdrawn from the earth.

In an appendix to Dr. Ferguson's paper in the eighth volume of the *Medico-Chirurgical Transactions*, Mr. Ralph makes the following statement:—

"By a calculation made from the above table, it appears that in the month of August, one case of fever presented itself in every *twentieth* man of those quartered on the *ground floor*, and in each *thirtieth* man of those on the *upper floor*. During that part of the month of September which has elapsed, *each* *twenty-fourth* man was attacked with fever of those stationed in the upper rooms, and each *fourteenth* among those in the *lower*."

The proportion of sickness in the upper floor of this barrack is not so much less when contrasted with the lower floor, as is found in those reported above. It shows, however, that the same principle applies in all places in hot countries. The difference in favour of the barrack of Mr. Ralph might depend on the under floor being made of wood, whilst in the other cases it might be made of stone. That the ground floor in barracks are less healthy than the upper, has been observed even by unprofessional men, by officers in the army in hot countries, and their observations have been made without reference to whether malaria had or had not the property of specific gravity. Difficulties unfavourable to the idea that malaria has specific gravity present themselves at every turning. Its supposed disease-begetting power operates at the level of the sea, and at altitudes of three or four thousand feet. At these altitudes, in some situations, there are swamps, to which the malaria may be attributed, and this observation may not apply; but there are heights which are subjected to pestiferous diseases, and where, at the same time, there are no swamps to give birth to the malign cause. With the variations of electric tension there are no difficulties, as at all elevations, wherever evaporation is in operation this cause acts, and it may be, that other agencies produce changes in electric tension.

Mr. Julius Jeffreys, in a work on the proper management of the army in India, makes reference to the received opinion that malaria is ponderous. In a review of his work in the *Dublin Quarterly Journal*, the following extract is made:—

"To be as brief as possible. Many reasons may be adduced against the lodgment of European soldiers on a ground floor, which was universal when I was in India, and, I believe, is so still, and many and great advantages demonstrated in favour of an upper floor housing of them. In the first place, every person who has studied the habitudes of malaria well knows how exceedingly more rife it is, especially the malaria generating the fevers of India, near the surface of the ground. The *natives*, though as such they ought to be more exempt, are much more prone to attacks of fever, owing to their sleeping close to the ground, than the Europeans who lie at a somewhat higher level, even where both are equally under shelter. Other causes, no doubt, are also in operation, but this is a main one. In some countries, the inhabitants sleeping on an upper floor are almost exempt from the effects of malaria which is decimating ground-sleepers. The wealthier inhabitants of Calcutta live entirely on the upper floors of their houses."

There is no reason so strong against using the ground floor as a sleeping room for soldiers or any one else, as the readiness with which the floor on the ground in the inside partakes of the same electric condition as the ground outside, and thus acts prejudicially on those who are in contact with the floor. The ground floors are generally made of stone, because of the cooling properties which it possesses, and the properties are cooling just in proportion as they have the power of abstracting electricity from the body. Still further to effect the cooling, in these warm regions, water is sometimes poured over the floors, and this greatly aggravates the mischief, by bringing into operation the agency of evaporation, which actively reduces the electric tension of the floor, and renders it still more powerful for evil. Mr. Jeffreys attributes the superiority of the upper floors as sleeping apartments to their being inaccessible to malaria, as its ponderous property keeps it near the ground. How much more satisfactory the opinion, that on the upper floor the people are better insulated than those who are placed on the floor on the ground. The Europeans occupy a more elevated position in their houses than the natives. But these people, notwithstanding the advantage of acclimatization, suffer greatly more from epidemic diseases than the strangers. This arises from no other cause than the superiority of the circumstances of the one over the other. The native, by lying on the ground in close contact with an excellent conductor of electricity, suffers an abstraction of his vital powers. During sleep the bodily functions are comparatively inactive, and there is little elimination of nervous power; and when, in this unfavourable condition, the body is placed on the bare earth, there is immediately instituted an active abstracting operation, by which nervous power is drawn off from the body when it is least able to spare it. It very often happens in camp life, that, while the officers are sleeping in comparative safety, on an elevated bed, the private soldiers lying on the ground are suffering from some violent epidemic disease. The soldier in his blanket on the ground is exposed to incomparably more danger than his officer. Two feet above the surface is a very partial separation to escape the effects of the malaria on the ground around. It is certainly very ponderous, if it cannot rise two feet above the poor victims who are writhing at the side of their neighbours, who lie in comparative safety at a few inches higher up, on a bed of wood, or other good non-conducting material. Unless the malaria be all the more ponderous, it might be expected that the restlessness and strugglings of the victim, at the side of him who lies at so little greater elevation, would cause the weighty malaria to ascend over the bed of him who is only the few inches higher up.

The natives of India lie on the ground probably from necessity, as they have no elevated houses, and they have not been accustomed to use their powers of observation to discover the evil attending hut life. These huts are composed of the most perishable and defenceless materials; and of necessity the beds are on the bare turf, as the people are ignorant of the risk of such a place of rest. The Europeans in Calcutta, being better educated, and having more acutely observant powers than the poor aboriginal inhabitants, and withal, having a greater command of means, make their dwellings of a safe height, and instinctively occupy the upper floors. They are thus raised far above the mischievous malaria; or rather, are well insulated by good non-conducting material between them and the damp ground.

The reviewer of the work of Dr. Jeffreys makes the following remarks about the locating of the British troops in India:—" The results of the recent rebellion have proved to demonstration that small bodies of Europeans, placed under any good cover and behind a rampart, fairly provisioned, can hold out for any reasonable period against vast bodies of natives. For the future, therefore, it is clear that by far the larger proportion of the European troops can be stationed with safety on hill eminences; and the choicest climates for the residences of Europeans are to be found in the hill districts of each of the Presidencies, at elevations of from five to six thousand feet above the sea." The superior salubrity of the hill districts depends on their mere elevation, and consequent greater dryness of the soil; and this dryness of the soil arises, because the water cannot lie on it to necessitate evaporation, and thereby produce resulting low electric tension. It is not the great height which secures the immunity, but more particularly the *summit.* The extreme point of a height, having in its vicinity no hollow to contain water, must, of necessity, be the driest position, as water by its gravity will always seek the lowest level. Any part of the side of a hill will not be dry till the portion above it be first dried. The residence, therefore, of soldiers should always be built on the top of an eminence. Two or three hundred feet above the most pestiferous plain, provided the height be completely dry, and composed of no unusually good conducting mineral, will be as salubrious as a position many miles distant or 1,000 feet higher. The barracks for the accommodation of soldiers in hot countries ought always to be placed in situations with a view to their having a dry foundation, and to their being in a position to keep them dry. If there is any flat part of a summit on which a barrack is placed where water can rest, it ought to be drained, to secure perfect dryness around the dwelling. There might, indeed, notwithstanding the good condition of the hill, be a source of insalubrity from another cause. There might be a long continued and strong current of damp air from the swampy plain, the properties and effects of which, on the inhabitants of the heights, resemble those which the Sirocco has on the inhabitants of the northern shores of the Mediterranean; but this is the only cause that could unfavourably affect the inhabitants of a dry elevation of 200 or 300 feet. If correspondence with the plain were indispensable, it would be a great inconvenience to the troops to have their habitations at such a height as 5,000 or 6,000 feet. If the principles here advanced be correct, it will certainly be more desirable to occupy the lower level.

The accommodation of the soldier in camp life is of as much importance as the living in barracks. There he is exposed to very injurious influences. Obliged to squat on the ground in all conditions, and fall under the influence of an enemy, in the ground on which he lies, that kills far more than the sword. The accommodation of the soldier in the field is of pressing consequence to the welfare of the men and the efficiency of the army in active service. When the soldier lies on the ground, unless it is quite dry, he places himself in close contact with an enemy much more formidable than that against which he is engaged with his musket. A much larger number of the soldiers before Sebastopol fell by diseases produced by being laid at night on the bare ground, than perished in the ramparts by the shot and shell of the enemy. When the soldier so often risks and sacrifices his life to keep the enemy far from our shores, some method for the preservation of his life against the elements of nature is indispensable. During action, in the hurry and bustle of the field, it is often impossible to make sufficient provision for the comfort of the soldier; but the highest and driest available part of the field is the best on which to pitch the tent. An impermeable canvas above, and a good non-conducting body to lie on, are all that can be expected in the field; and they are indispensable for the preservation of the lives of the men. An air mattress would be the best possible couch for a soldier to sleep on under the canvas, and the most convenient to be carried about. It can be inflated at pleasure, and, when the air is expelled, can be compressed into small bulk; and may be easily carried about. The side of the mattress which is placed next the ground, might be well oiled, and this would make it all the more non-conducting, and the less attractive for water. The air with which the mattress is inflated is also a bad conductor of electricity, and will therefore serve well for effective insulation.

An objection to this provision for the soldier might be urged on the score of expense. But, if it be found that, by adopting these measures, disease is warded off, and the life of the soldier lengthened in the field, a more than compensatory saving to the country might be accomplished by the less necessity for recruits and transports. The soldier has a right to demand of his country that, when he is asleep on the field, he be as safe and comfortable as possible, and sufficiently guarded from an insidious foe in the very ground on which he lies, seeing that he may, at the risk of his life, have to face his enemy next morning. In the choice of a spot on which to lie, the soldier ought to select a spot that is dry, and thoroughly so, if this is attainable; and if dry grass or straw can be had, this ought to be placed below the mattress, which will still further insulate his bed, and place him in greater safety. It may be objected that this delicate caring for the soldier in the field is not consistent with the hardening necessary to form the veteran. Is it not hardening enough to sleep under the open canopy of heaven, exposed to the chilling of the night air, and the wetting dews of heaven? It is enough, surely, that all these unfavourable influences be borne, without having superadded, the operation of a very unfavourable instrumentality from below. It is short-sighted policy to allow a large portion of vigorous young soldiers to die of pestilential disease, in order that those who may escape may be looked upon as veterans.

In a former part of this work, reference is made to the insalubrious condition of what is called the neutral ground at Gibraltar. There the best means have not been adopted to protect the soldier. The station is established on a hidden swamp. During the heat of the day there is evaporation, but at night the vapour is again condensed. If a military station must be continued in this exact spot, the soldiers ought to be put as far as possible beyond the dangers with which they are encompassed. Elevating their residence would further this object. In a situation without any natural eminence, recourse may be had to artificial elevation, by driving wooden piles into the ground, leaving the ends projecting ten or twelve feet above the surface. The house is to be built on these piles. If the men were placed on air or hair mattresses in such a house, they might sleep with comparative safety in spite of the dangers surrounding them. A platform might be constructed around the house to accommodate the soldiers on duty during the night, and a box on the same platform to defend the sentinel from the dews. The men ought not to be allowed to be out in the open air after nightfall, as then, in such a situation, the surface over which they tread is in a highly negative condition.

CHAPTER X.

ON THE OPINIONS OF AUTHORS ON THE INFLUENCE OF ELECTRICITY IN PRODUCING DISEASE.

It is only when a motive is presented, when an object of pursuit is placed before the mind, that an effort will be made to attain the object pursued. The connexion of the cause of disease with variations of electric tension has not been thought of, and, therefore, facts best qualified to establish these views have not been purposely sought after, but have only incidentally and by accident been caught up by an intelligent observer, and forthwith placed on record. A single observer, by residing in a favourable position in that portion of the earth where there is the greatest extent of electric fluctuation, might accumulate a certain number of facts; but no effort, however enduring, nor the most persevering industry, could produce a sufficient number of facts to establish a principle which is for the first time brought before the profession. The observations, therefore, which have been brought together could not have been made originally with any reference to support the views here advocated, and, on this account, will not be so relevant to the subject as they might have been if they had been sought after with a different aim. When electricity is adverted to as a cause of disease, it is the negative condition of this agent which is considered as instrumental in producing the evil. Dr. Copland frequently makes allusion to electric agency as a cause of disease; and the negative condition is that which he always mentions. In his article on Septic Pestilence, he states that "by great humidity and stillness of the air, and probably also with a negative state of the electro-motive influence in the atmosphere and in the earth's surface, ... and a combination of conditions, ... are sufficient to generate a pestilential malady." The doctor admits only the probability of electric agency in producing pestilential disease, and of its operation through the air. Now, it is the persistence in attributing this malign agency to the electricity of the air, that has hitherto prevented a proper appreciation of the instrumentality of the variation of electric tension as a cause of disease. Free electricity is most abundant in the air when this fluid is laden with moisture; and it is not the electricity in the moist air which has any injurious effect, but the moisture only; as in this condition it has a large capacity for more electricity, and exacts the electric fluid from every object that is more positive with which it comes in contact. It is the abstracting property of the moisture which has the malign effect on the human body. The doctor makes allusion also to the negative state of the earth's surface as being influential in causing disease. The operation of this condition of the earth has been fully recognised as being instrumental in producing disease. In various parts of his Dictionary, the doctor makes allusion to the operation of the electro-motive agency, but makes no mention of the manner in which the electricity operates so as to produce the disease. Writers whom the author has consulted, and who make observations on electricity in connexion with disease, always refer to the negative condition of this agent, as if the evils were produced by a lack of electricity; and it is to this condition of this fluid that Dr. Copland attributes any influence he thinks it has in producing epidemics. The positive condition is not referred to as being operative in the development of disease; it is always the negative.

Dr. Littell, in a paper entitled "On the Influence of Electrical Fluctuations as a Cause of Disease," in the *North American Medico-Chirurgical Review*, wherein he gives an exposition of his views, makes the following remarks:—

"Whether operations going on in the interior of the earth do not influence the electrical condition of its surface is a subject which may demand investigation.* The prevalence of cholera during the past year in Sicily, Madeira, and Central America—all of them volcanic countries—would seem to give some plausibility to the conjecture. The air of the Pontine marshes, near Rome, so fatal to those within its influence, is deficient in electricity, and possibly from the same cause. But it may be remarked, in passing, that the air of marshes, and still water generally, is more prejudicial than that of rivers or running streams; partly for the same reason, that the air, saturated with moisture undisturbed by atmospherical currents, and possessing, therefore,

* The proximity of such operations to the surface of the earth, and the nature of its crust influencing its conducting power, would, of course, render some places more liable to be affected than others.

more active conducting power, lingers upon them in unbroken mass, long impervious to the rays of the sun; and partly because, in the latter case, the motion of the particles among themselves, and their friction against the hills, trees, &c., when driven by the winds, is itself a principal cause of atmospherical electricity. It is probably in both of these ways that the agitation of the air by the frequent passage of a steamboat—itself a most active hydro-electric machine—increases the salubrity of places in its vicinity, or restores it when lost, as, for instance, in the case of the Schuylkill above the dam at Fairmount. The meteorological constitution in which influenza appears, would incline us to predict with confidence the origin of that complaint in defective electricity; and most of the diseases to which I have before alluded are notoriously most frequent in seasons of the year when electrical currents and changes are greatest, and their injurious operation aggravated by moisture and other auxiliary influences. There are many facts, moreover, irreconcilable with the commonly received notion of the malarious production of fever; and without absolutely denying the deleterious action on the animal economy of exhalations from decaying vegetable matter, I am fully convinced that these are not the general cause of the disease, and that a part far too prominent and exclusive has been attributed to their agency. The theory afforded a plausible solution of many things hard to be understood, and, being supported by a multitude of seeming facts, has been too hastily received and adopted by the profession. The complaints supposed to be thus engendered prevail at a season when electrical vicissitudes are greatest, and the body, debilitated and otherwise disordered by the protracted heat of summer, is most sensible to their impression."

As has been already stated, it is the opinion of the author, that operations are going on in the interior of the earth, which influence the electricity on its surface. It is scarcely correct to state that the air over the Pontine marshes is deficient in electricity. It would be more correct to state that the moist air of this pestiferous region has a large capacity for electricity—a great power for exacting it from every positive body presented to it, and especially from the human body, which is always positive in relation to the objects around. It has been shown above, that still deep water is not found to be deleterious, when the banks of the place in which the water is confined are steep, and not low and muddy. It is more probable that the atmosphere depends for its electricity on that which is carried up with the vapour that is raised, than that produced by friction against the hills and trees. Dr. Littell is at one with the author, when he considers that the influenza referred to by him was produced by defective electricity, and that, simply, by the action of the negative condition of that portion of the earth occupied by those who suffered from the influenza. Decaying vegetable matter is deleterious, only in so far as it serves to hold the water which supplies the vapour to carry off the electricity, and produce the negative condition. No reliance can be placed on the influence of the exhalations (leaving out of consideration the watery vapour) which arise from the swamps, and the decaying vegetation. We cannot step into a field without treading on decayed vegetation; yet who dreams of danger arising from the decaying and decayed grass of the field?

In another part of his paper, Dr. Littell states that "the air of the sea, and generally of places in its vicinity, though saturated with moisture, is healthy for this reason, for this moisture being general and invariable, tends to maintain the electrical equilibrium, though perhaps at a lower range; while the system being less enfeebled and disordered by heat, the atmosphere purer and denser, and the nights cooler and more refreshing, such fluctuations as do occur are less sensibly felt. Hence also it is that in a very rainy season, localities which have been the immemorial haunts of fever, become comparatively healthy; while upland districts, rarely visited by it, suffer in their turn." The air of the sea, though containing a large quantity of moisture, is yet not so loaded with it as the air over the land frequently is. When the surface of the land is saturated by the rain, and after this exposed to the rays of the sun, there will be an immense quantity of moisture in the air, as the soil from which the water is taken up by evaporation becomes very much more heated than the ocean, and this causes a very moist state of the atmosphere. The reason why unhealthy damp situations become more healthy by being made more damp, arises in this way. The usual dampness of the swampy region is only to the extent of partially covering the ground, or merely preserving the soil in a wet condition. This soil, being heated with the water in it, rises to a very high temperature, and causes a quick and copious evaporation, causing great fluctuations in electric tension, producing a negative condition of the locality, causing nervous abstraction, and the consequent derangements attendant thereon. There is a good illustration of this in the watercourses of hot countries, which are dried up by the heat of the sun. When the water fills the courses, there is found no unhealthiness in their vicinity; but as soon as the water has disappeared, the bottom of the course continues long wet, and the sun heats it to a high temperature, and thus produces a large amount of evaporation, and consequent hazard of disease. On the other hand, when this sickly neighbourhood during very rainy weather becomes like a lake or inland sea, the water in such quantity never becomes so heated as the water merely wetting the soil, and cannot cause so much evaporation. The reason why the "upland districts" became more sickly, is that the soil is much more wetted than usual, and yields a larger amount of vapour when acted on by the sun, causing a great degree of electric variation, producing in the soil a more highly negative condition; and by this more than usually powerful agency are the people injuriously acted upon.

In a paper entitled "On the Origin of Malaria," in the *Glasgow Medical Journal*, Mr. Nash states, that it is his belief that there is a movement in progress to evoke a general law—to find out an adequate and all-prevailing cause, to displace the disjointed opinions which have hitherto prevailed on such an important subject, as the etiology of disease. He says, "I, then, believe malaria in its causes and *modus operandi* to be a diminished innervation induced by a negative electrical state of the atmosphere." He then gives the results of the diminished innervation in the development of certain diseased conditions of the body. He states, as one of the results of this diminished innervation, that the blood is much altered both in appearance and consistence. He mentions, too, that the capillaries of the intestinal canal lose their nervous supply, and so become relaxed, suffering the escape of their contents, not of serum only, but of the whole changed blood. He mentions several places which are most notoriously unhealthy, and which, at the same time, are of low electric tension. He adverts, also, to several places, where the minerals are characterised by being composed of magnetic oxide of iron, and rocks of the same formation, as being known for their insalubrity. Mr. Nash mentions a place quite uninhabitable because of the negative condition of the rocks, and closely analogous to that mentioned by the author in the *London Medical Gazette* for 1851. In another part of his later paper he says:—"For these I only ask this concession, that they exhibit the circumstances necessary for electric negativity (to coin a word) without those suited to develop either of the other hypotheses. These conditions are, however, very limited, and we must now briefly group another dangerous series. Of these we find the Campagna di Roma may stand as a type; here the negative electricity cannot be produced by magnetic agency, but the volcanic decompositions will afford a solution. The meteorological journals, both at Rome and the more accurate ones at Bologna, agree in ascribing a low electric tension to quiescent volcanic phenomena, while even popular opinion and statistics are agreed in one fact, that a volcanic outbreak clears away malaria, and that the period just before an outbreak is proverbially unhealthy."

There is no difficulty in admitting that in volcanic districts great fluctuations occur in the electric tension of the earth, as there the internal combustion must be varying, both in situation and intensity; and the electric condition of the surface above must always participate in the changes below. The manner in which the volcanic outbreak clears away the malaria is, that the excessive heat of the molten lava, which is thrown out on the locality, puts it in a highly positive condition. In such a situation as that of the Campagna di Roma, where the air is almost always steaming with moisture from the exhalations continually rising up, there will not be much difficulty in discovering what is the source of the evil. Indeed, both may be operative, or, it may be, that the whole three are active; the moisture in the air, acting on the exposed surface of the body, abstracting nervous power, and the negative condition of the earth produced both by evaporation and volcanic action. Mr. Nash mentions several other places known for their insalubrity, which have their electric relations disturbed, and are in a negative state. Again, he gives the following interesting passage:—

"I only ask to add, then, another group of localities deficient in the former requisites for electro-negative action, but agreeing in the morbid phenomena, and in possessing the materials for electric disturbance, from another source. Turning now to this group, we shall take the tidal bays and streams of the Gold and Slave Coast, and the fresh water bays of the Mississippi, as types of this class of miasm homes: here we shall find the low electric tension, but none of the former agencies to account for it; we have one, however, in the high temperature co-existent with the almost saturated damp atmosphere. All electricians are familiar with the difficulty of inducing positive, or, indeed, any electric phenomena in a warm crowded room, and a moment's reflection must show that such an atmosphere must drain electricity from the system most rapidly, thereby causing diminished innervation when the drain is beyond the supply. As yet, there is an assumption that electric drain and diminished innervation are in the relation of cause and effect; but I only ask the admission that, in these localities, circumstances exist which would render the atmosphere negatively electric; or, in other words, capable of receiving electricity from any source where it may be generated.

"Reviewing, then, the groups of dangerous localities, we shall have an electro negative state, induced in the first by the conducting magnetic oxide, in the second by volcanic agency, in the third by a high temperature and saturated soil—all disagreeing in every relation but that one. I do not yet know of a dangerous site where none of these exist; when I find one where constant positive electric atmospheres co-exist with malaria, I will deem the theory shaken, though not thrown down. But the assumption of the necessary co-existence of negative electricity and nervous prostration, requires examination. The evidence for this must be chiefly negative; we are not justified in tampering with human life so far as to place persons under circumstances where these effects may be produced. But a few experiments may be tried for preventing such a state. The following experiments were suggested by the fact, that the dwellers amidst these dangers are in the habit of sleeping as high above the ground as possible; this admitted of two explanations, either that the miasm possessed great specific gravity, or that the conducting power of the earth was less in proportion to the quantity of atmosphere intervening. By my suggestion, some bedsteads were made of wood, and the legs secured to glass insulators; the mattresses and coverings were composed of silk—at least, wherever we could, we adopted silk; and a series of experiments at the hospital in Port Royal indicated, that the more the patients were insulated, the better they were. Here, obviously, the electric relations alone vary—insulation could not alter the effects of a paludal emanation or a sulphuret. The other patients slept in metallic bedsteads, without any other variations, in the ward."

The "miasm homes" on the West Coast of Africa and in the valley of the Mississippi are characterised by a low electric tension which is produced by copious evaporation from the earth, and it is not only the moist air which operates prejudicially on animal life, but also the negative earth which has been made so by the exaction of this very vapour which contaminates the air. If the coast of Africa and the valley of the Mississippi were always in a negative condition, these situations would be uninhabitable, as there would be a continual draught of nervous power from any animal in contact with them. The electric condition of these regions in relation to the human body will be sometimes negative, sometimes positive. During the day, when the sun shines, the surface of the earth will be positive in regard to the living animal, and then it will be safe to be in contact with it; as nervous power may be attracted from the electro-positive state of the earth. At night, when the sun is withdrawn and the evaporation is continued, the human body will part with its electricity, and will be injured in proportion to the amount withdrawn.

The vapour in a crowded room is not necessarily mischievous to the people in the crowded room from any electro-negative consideration, although electricians cannot procure electricity. The fire and light in the room, and the radiation from the bodies of the people, will cause a large concentration of electricity, although that form of it procured by electric machines cannot be made apparent. Suffering might arise from other causes, such as the vitiation of the atmosphere of the room by the large quantity of expired air necessarily concentrated in a room containing a large number of people. The sudden emergence into a cold night air would abstract electricity copiously from the nervous system, and might be hurtful to those who, by mental excitement and corporeal effort, have already wasted a large amount of nervous power.

In the second paragraph of the quotation, Mr. Nash expresses his conviction that all dangerous places are electro-negative. There is no habitable locality that is constantly electro-negative, *i. e.*, electro-negative in relation to the human body, as then a continual abstraction would be going on from the nervous forces. The greater number of those dangerous places that are habitable are sometimes positive and sometimes negative. During the day, whilst the sun shines, these localities are positive; but at night, when the sun has ceased to shine, they are of necessity negative. Wherever the magnetic oxide of iron, more especially the ferruginous variety of disintegrated rocks, prevails, it is always negative and always dangerous. The situations which are positive at all times, are found to be healthy. The desert is always in a positive condition, and no diseases prevail there.

If the Port Royal mentioned above is the Port Royal in the West Indies, it was a very fitting place for instituting the experiments there adverted to. It is not mentioned whether these experiments were made on the ground floor, or on an upper floor. If on the latter, it would of necessity be made of wood, and, as this is a bad conductor of electricity, it would consequently insulate the beds in a great measure, independently of the other expedient. On the ground floor the experiments would have been more satisfactory, provided the floor was made of stone or the bare earth, as in this kind of floor there would have been a good conducting medium in connexion with the ground outside. If a patient had continued on an iron bed on such a floor, and another on a carefully insulated bed, the difference would have been more apparent. Port Royal is notoriously unhealthy.

Experiments are the most satisfactory method of eliciting truth, and, in so far as they go, they confirm the view that a negative condition of the earth is injurious to human health. With such an instrumentality as the sun operating on the surface of the earth, we do not want experiments. And to a greater or less extent, according as his rays descend at a less or greater angle, does he operate in causing variety of climate, and, at the same time, the variety of electric changes which are continually going on. There are, in this large field, experiments of a most magnificent character continually in progress, which, if observed by minds intelligent and industrious enough to understand the phenomena of nature, there might be accumulated an array of facts which would go far to settle many important, and, in the meantime, dark questions.

CHAPTER XI.

ON VARIATIONS OF ELECTRIC TENSION AS THE CAUSE OF INTERMITTENT FEVER.

Intermittent fever is another disease which manifestly arises and depends on those conditions of a locality which favour fluctuations of electric tension. When the people of a country labouring under this disease, and having marshes around them, speedily and permanently become free of this complaint by the drainage of the swamp and the thorough drying of the ground, there can be no doubt of the connexion of the fever with the existence of the marsh. If it were found, moreover, that during the continuance of the swamps, the locality around was generally in a more negatively electric state than after they have been removed, and the more so, if when the site they occupied has become thoroughly dry and salubrious, it would be reasonable to conclude that there is a connexion between the increased salubrity of the locality and the increase of electric tension. There is a physical necessity for the greater electric tension of a country in a dry state, and at an elevated temperature, than of one in a wet state, as the electricity which would remain in the soil is carried up when the water is raised. In the dry state of the ground, when the sun shines, the electricity communicated to the soil by this luminary is retained to a great extent in it, as the air is a bad conductor of the electricity, and has little power to exact it from the animals in contact with it; and on this ground does its salubrity depend. In assigning a remote cause for the existence of intermittent fever, it is not encumbered with the question of contagion, as all writers agree that intermittent fever is a product of malaria.

Now, it is admitted that ague cannot be produced without the existence of marshes, or an equivalent. Indeed, in those regions where the equivalent exists, it is not intermittents that generally prevail, but remittents and more severe diseases. It has been remarked by some writers that there are marshes in Scotland and Ireland, called peat bogs, unassociated with intermittents. Dr. Watson, in his *Practice of Physic*, vol. i., page 722, says :—

"No very certain or extensive observations have yet been made in respect to the *kind of soil* from which the miasmata are more apt to be extracted. Such as is loose, penetrable, porous, and sandy, appears highly favourable to their formation. So are soils which, containing much clay, are very retentive of moisture. One curious fact, however, bearing upon this question seems to have been made out; viz., that what is termed peat bog, or peat moss, is not productive of malaria. Many parts of Scotland and of Ireland, that are occupied by large tracts of marsh in which the peat moss abounds, are completely free from these fevers. Dr. Bissett affirms that the exhalations from black peat moss do not occasion intermittents, 'at least in high moors under a clear sharp air.' Now, in the climate of Virginia, this counteracting influence of a sharp air can scarcely be looked for; yet it is a remarkable fact, that though the provinces of North America, especially North and South Carolina and Virginia, are full of ague, that disease is never seen among the inhabitants near the country of the *Dismal Swamp*, a moist tract of 150,000 acres on the frontiers of Virginia and North Carolina. Weld, the traveller, informs us that this immense tract is covered with trees, and abounds with water, which appears the moment the shallowest trench is dug. The water is brown, like brandy, but quite clear and not unpalatable. Its colour is ascribed by the inhabitants to the roots of juniper, and it is said to be diuretic (CRAIGIE)."

That no intermittent fevers arise from peat moss is a fact well known in Scotland and Ireland. This apparently arises from the ligneous nature of the soil. There is so much decayed wood in the substance of the bog, as to make it an excellent fuel for the people who reside near it. The water in these bogs never gets so heated as it does in the marshes over alluvial soils, and consequently there is not so much evaporation. The reason that the water is never of such a high temperature in the bog is because of the non-conducting property of the peat marsh. The wood does not become heated like substances composing other marshes, and consequently there will be less evaporation, and less chance of low electric tension. The alluvial soil just covered with water, and the loose, porous, sandy soil, above mentioned, or any other kind of mineral *débris*, are good conductors of electricity, and consequently soon become heated by the rays of the sun, and very soon become cooled, when the rays are withdrawn, by continuing to heat the water which is raised by evaporation.

The Dismal Swamp above mentioned may be free from intermittents on the following grounds:—1st. There is too much water in the soil to be easily heated to produce evaporation. 2nd. It is stated that the water is in contact with juniper roots, and they are bad conductors of electricity; and it is probable that they are of great number, as they are stated to have coloured the water. 3rd. There are the trees which will prevent the sun from beating on the water, and in this way it will be kept comparatively cool and cause little evaporation, affecting but slightly the electric tension of the locality.

The phenomena which are exhibited at the onset of a paroxysm of intermittent fever can be explained very satisfactorily on these principles. It is a complaint that evidently depends on a continually operating agency in certain localities. As in other diseases, so in ague there are symptoms of lost power, all attributable to nervous failure; and persons will be affected, sooner or later, according to the strength and resisting powers of their nervous system. A stranger of robust constitution, on entering a marshy district, does not feel all at once the evil effects of the locality. He may, according to the vigour of his constitution, be able to bear up against the unfavourable influences with which he is surrounded for a longer or shorter period. But, though unknown to himself, the exacting power begins as soon as he goes within the range of the unhealthy region. The vigour of his constitution bears up for a considerable time. He eats well, his digestive organs work powerfully, and his respiratory organs act freely. All the while that this healthy action is progressing, there has been a continually exacting operation going on. The redundant caloric, which is always radiating from the body, is given off in a dry state of the air and positive condition of the soil with impunity. But in a wet and negative state of the soil, and a damp state of the air, circumstances become changed. He is now surrounded by good conducting media, and more is ultimately drawn off than the nervous system can well spare, and then derangements begin. On the shores of some of the pestiferous islands in the West Indies, the exacting power is so strong, as in a single night to strike down a healthy man with a much more dangerous disease than is produced by the slow operation of a marsh in a temperate climate.

Dr. Watson gives the following very clear and distinct account of a first paroxysm of this disease:*—

"A person who is on the brink of a paroxysm of ague, experiences a sensation of debility and distress about his epigastrium, becomes weak, languid, listless, and unable to make any bodily or mental exertion. He begins to sigh, and yawn, and stretch himself; and he soon feels chilly, particularly in the back along the course of the spine; the blood deserts the superficial capillaries; he grows pale, his features shrink, and his skin is rendered dry and rough, and drawn up into little prominences, such as may at any time be produced by exposure to external cold, and presenting an appearance somewhat like the skin of a plucked goose—hence it is called goose's skin, and in Latin *cutis anserina*. Presently

* Vol. i. p. 703.

the slight and fleeting sensation of cold, first felt creeping along the back, becomes more decided and more general; the patient *feels* very cold, and he *acts* and *looks* just as a man does who is exposed to intense cold, and subdued by it: he trembles and shivers all over; his teeth chatter, and sometimes so violently that such as were loose have been shaken out; his knees knock together, his hair bristles slightly, from the constricted state of the integuments of the scalp; his face, lips, ears, and nails turn blue; rings which before fitted closely to his fingers become loose; his respiration is quick and anxious; his pulse frequent sometimes, but feeble; and he complains of pains in his head, back, and loins; all the secretions are usually diminished; he may make water often, though generally he voids but little, and it is pale and aqueous; his bowels are confined, and his tongue is white and dry.

"After this state of general distress has lasted for a certain time, it is succeeded by another of quite an opposite kind. The cold shivering begins to alternate with flushes of heat, which usually commence about the face and neck. By degrees the coldness ceases entirely, the skin recovers its natural colour and smoothness, the collapsed features and shrunken extremities resume their ordinary condition and bulk. But the reaction does not stop here; it goes beyond the healthy line. The face becomes red and tinged, the general surface hot, pungent and dry; the temples throb; a new kind of headache is induced; the pulse becomes full and strong, as well as rapid; the breathing is again deep, but oppressed; the urine is still scanty, but it is now high coloured; the patient is exceedingly uncomfortable and restless. At length another change comes over him: the skin, which, from being pale and rough, had become hot and level, but harsh, now recovers its natural softness; a moisture appears on the forehead and face; presently a copious and universal sweat breaks forth, with great relief to the feelings of the patients; the thirst ceases; the tongue becomes moist; the urine plentiful, but turbid; the pulse regains its natural force and frequency; the pains depart; and by and by the sweating also terminates, and the patient is again as well or nearly as well as ever."

The chilliness, the languor, the fatigue, the sighing, the yawning, the shivering, and the chattering of the teeth, are all evidently referrible to failure, and irregular action of the nervous power. The internal oppressions arise from the internal fluid accumulations. Paleness and dryness of the skin, collapse of the countenance, all arise from the departure of the fluids from the surface. Labouring respiration may depend on the reduced power of the nerves of the lungs, and congestion of the capillary structure. The pain of head and aching of the loins may also depend on congestion of the capillaries of their structures. The contracted, small, and weak pulse may partly depend on lessened power of the nerves supplying the heart, and the obstructed sanguineous current produced by the internal congestions. It is not possible that so much turmoil in the corporeal operations could take place without producing an unfavourable effect on the animal body. The action of the secretory and excretory organs are, in a great measure, suspended during the paroxysm, and, as a consequence, the circulating fluid is left undepurated, and must contain what ought to have been thrown off both by the skin and kidneys. The hot stage of the paroxysm evidently results from the efforts of the system to regain its healthy condition. The circulating fluid is sent back to the surface. In the third stage, the perspiratory functions are again actively established, and the skin flows with perspiration. The kidneys also regain their depurating powers, as the urine becomes loaded with the bodies which are usually thrown off in this secretion. Notwithstanding the restoration of the power of the depurating organs, the blood cannot be left in the same healthy condition after a paroxysm of this nature, as it was before it took place; as, before a sufficient time is allowed for nature to restore completely to its wonted condition this vital fluid, there is another onset of the violent symptoms, followed by the same damaging results. Therefore, before the blood can return to its normal state, it is again subjected to another adulterating process, and afterwards another effort is made to get well; and at every repeated attack, with these struggles to get well, there will be an additional adulteration of the blood, and the impure sanguineous fluid, in its course through the body, will be depositing in the various organs of the body those elements which ought to have been thrown out; and hence the many diseases which are known to be produced in various organs, by the irritation of elements deposited in their structure, which ought never to be there. That numerous diseases have arisen, as the results of repeated paroxysms of intermittent fever, is apparent from the following statement of morbid appearances in fatal cases of this disease by Dr. Copland:*—

"*Death* may take place either from overpowering congestions on the cold stage, or from rupture of the spleen; but it most frequently results from the superinduced disease of internal viscera in connexion with exhausted organic nervous power, and sometimes with a morbid state of the circulating fluids, particularly in the adynamic and complicated forms. The chief lesions are situated in the liver, spleen, digestive mucous surface, and lungs. *a.* The *liver* is often enlarged, its consistence being either increased or diminished; tubercular or purulent formations being, moreover, dispersed through its substance. Increased consistence or density, softening, purulent, or tubercular formations, &c., may also exist, separately or in various combinations. Engorgement of the vessels with dark blood; distension of the hepatic ducts and gall bladder, with a dark or greenish, black, thick, and viscid bile; thickening and injection of the ducts and gall-bladder, &c., are often observed in connexion with other lesions, but more especially with enlargement and softening of the substance of this viscus. *b.* The *spleen* is often remarkably enlarged. MORGAGNI and GROTTANELLI found it to weigh eight pounds. In some localities, it occasionally reaches an enormous size. On the Gold Coast of Africa, it has been found double this weight in Europeans. I saw a case in which it was nearly eleven pounds. Its envelope sometimes presents appearances of chronic inflammation—is injected, thickened, and almost cartilaginous. Its consistence internally is rarely increased; but is

* Vol. i. p. 936.

most frequently diminished; its structure being friable, oftener almost diffluent, or consisting of a greyish black semi-fluid substance, traversed by greyish fibrous shreds or fibres, and containing a sanguineous fluid of a purplish hue, or resembling wine lees. Instances have also occurred where adhesions have formed between the spleen and stomach, and between the spleen and colon in others; another thick black blood of this viscous has thus been discharged into the digestive canal by ulceration, the matters passed from the bowels or thrown off the stomach presenting a blackish appearance. (Morelli, Gaste, Bailly.) *c.* The digestive mucous surface is—in various parts—in the ilium, the cœcum, colon, stomach, duodenum, and œsophagus, more or less altered; often softened; injected with dark blood in patches or spots; and occasionally ecchymosed. The mucous follicles are frequently enlarged or inflamed in various parts. *Ulceration* is seldom observed, unless the disease has been complicated with diarrhœa or dysentery; and that this lesion, with thickening and softening of the coats of the bowels, especially of the cœcum and large bowels, and peritoneal injection, is generally observed. *d.* The *mesenteric glands* are sometimes enlarged, and present signs of obstruction or of chronic inflammation, more especially when lesions of the digestive canal are very remarkable. *e.* The *pancreas* is occasionally enlarged in some instances, so as to obstruct by its pressure the common bile-duct. *f.* The *lungs* are sometimes congested; but seldom otherwise changed unless pulmonary complications have existed when similar lesions to those described above (§ 53) are observed. *g.* The *brain* and *its membranes* are not often much altered unless in the comparatively rare cases in which coma has attended the fit; or apoplexy, or convulsions, or paralysis has occurred in it; when congestion, injection of the pia mater, effusions of serum between the membranes, or in the ventricles, are the usual appearances. *h. Dropsical effusions*, especially in the peritoneal cavity and cellular tissue; a pale, flaccid, and softened state of the structure of the *heart*, and more or less discolouration of a yellowish, or lurid, or dirty hue, are sometimes also observed in the more adynamic or protracted cases."

With such an array of corporeal derangements as the result of this disease, it is evident that there is a powerfully mischievous agency at work in those regions where ague prevails. This agency, in its abstracting operation, may be so powerful as to weaken the nervous force so much in certain weak constitutions as to render them unable to determine the blood to the surface to terminate the cold stage. As a consequence of this, the internal congestions will be so prolonged as to produce permanent dilatation, and sometimes rupture of the capillaries of some delicate organ, and thus assist in causing a fatal result. The "exhausted organic nervous power" is the result of the abstracting agency of the negative soil, and the good conducting property of the moisture over the marsh. The "morbid state of the circulating fluid" is produced by failure of the nervous power of the organs employed in its depuration, as those bodies are allowed to remain in it, which it is their office to throw out. With the blood in a morbid condition, that is, containing less or more of those substances which the various organs in their healthy condition throw out of the system, it is not surprising that so many morbid appearances result after oft-repeated paroxysms of this disease. The thickenings, the enlargements, the hardenings, the softenings, the injections, the engorgements, the distensions, the obstructions, are all attributable to the altered condition of the circulating fluid having difficulty in its course through those small vessels. The corpuscles of the blood being altered in their consistence and their size, may either cause distension or rupture according to the resisting force of the walls of these small vessels, as may be exhibited in the lesions above indicated.

There are no other principles on which such a large amount of morbid appearances, as often exist in fatal cases of intermittent fever, could be more satisfactorily accounted for than that the blood is deteriorated, and that the deterioration arises from depressed nervous power, unfitting the vital organs for performing their various depurating functions; and that this nervous failure or depression is the result of the power being abstracted by a low electric tension of the soil on which the person is placed or of his being operated on by a moist atmosphere. There is a great difference in the intensity of the injurious influences which arise from different marshes, and there are worse and better seasons in the same marsh. In the wet season, when the marsh is covered with water, when it resembles a lake, it is tolerably healthy. As it begins, however, to dry up, the insalubrity returns, and it becomes more intensely insalubrious in proportion to the speed with which the drying process acts till it becomes perfectly dry, and then it is perfectly healthy. The cause of this gradation in insalubrity in a marsh is as follows :—Whilst the marsh is completely covered with water, there is comparatively little evaporation, and a proportionably partial effect on the electric tension of the locality. In proportion, however, as the drying process goes on, the soil begins to appear and to be acted on by the rays of the sun, and now the water in contact with the soil becomes very much heated, and the evaporation goes on with increased intensity. If this drying process be not interrupted by a fall of rain, it ultimately makes the marsh completely dry, and then the electricity of the locality is not drawn off, but is left in it, and causes it to be in a highly positive condition, when it will be perfectly healthy, as it will support the nervous powers of all those who are under the influence of the locality. It is found that a marsh is more injurious at one time of the day than at another. During the day, though the vapour is raised in greatest quantity, yet the heat is not all carried off, as a large quantity remains, sufficient to support the neuro-electric powers in a normal condition. But at night, when the sun has retired, the heat left in the soil by his rays causes the evaporation of the water in the marsh to continue, and thus speedily puts the soil in an electro-negative condition. That moisture, independently of temperature, is the cause of epidemic intermittent fever, may be concluded from the circumstance that, when marshes are frozen, they are as healthy as when thoroughly dry. This has given rise to speculation as to how freezing has this effect. In a review of a work by Dr. Townsend, in the *Edinburgh Medical and Surgical Journal* for 1824, the reviewer represents Dr. Townsend as speculating on the question why the frost arrests the activity of malaria. The reviewer says:—"Akin to this strange speculation is the absurd opinion that frost decomposes the elements of this unknown agent. What proof can our author adduce that frost ever decomposes? We have known it condense, but never decompose; and it is generally regarded as the most powerful agent in arresting or preventing decomposition, both in solid and gaseous bodies." Although the reviewer condemns the opinion of his author, he does not venture to state one of his own. A dry air, independently altogether of temperature, is unfavourable to disease. Deserts as well as frozen marshes are unfavourable to febrile diseases; and there is here a great difference of temperature.

If the people in these insalubrious situations were to have their houses sufficiently elevated, they would escape the mischievous effects of the emanations from marshes, provided they did not expose themselves, in the absence of the sun, to the negative influence of the marshy neighbourhood. In marshy districts, where endemic diseases prevail, some of the dwelling-houses are considerably elevated above the surface, by means of wooden pillars, with a view to avoid the evil influences of the malarious emanations which are supposed to arise around them. This expedient has been adopted because, by experience and observation, it has been found in those countries that such an arrangement is more conducive to health than when the houses are on the ground. The author is not aware of the height necessary to be attained before the poison is divested of some of its virulence; but he would suspect that a much higher elevation would be required for a house to be safe than is consistent with the convenience of access before getting out of the way of the obscure destroyer. Although it is difficult, with the view hitherto entertained, to understand how the elevation of houses on pillars of wood should cause them to be more wholesome in malarious localities than those which are placed on the surface of the ground, yet, on the principles here maintained, a plausible and even satisfactory reason can be assigned. The wood which composes the pillars will, in tropical regions, be well baked by the heat, and the wood thus baked is converted into a good non-conductor of electricity. A house so situated is, in a great measure, insulated, and the inmates are thus defended against the abstracting power of the evaporating surface below. There is a security, too, that the floors of these elevated houses will be made of wood, and, if covered with a carpet, the wool will still further provide for the insulation. On the contrary, when the floors are made of stone, which of itself is a good conductor, and which of necessity must be near the surface, and will be affected with alterations of temperature, of dryness, and moisture, they will thus provide an excellent conductor of electricity, which will act on any part of the body which may be made to rest on it. The insulation of dwelling-houses, in marshy districts, will, on these principles, be of great importance. It is in their houses that people pass the greater portion of their time; and, if they were completely separated by insulation from the surface around, which, by the copious evaporation, is subjected to a largely diminished electric tension, they might escape those consequences that depend on an unfavourably altered condition in the electric relations. With reference to the insulation of the body, when out of doors, as the feet are more in contact with the earth and conducting surfaces than any other part of the body, it will evidently be important to have them well protected with good non-conducting substances. Wool and leather are in common use, and when the former substance is kept dry, the object is pretty well accomplished. Gutta-percha is a good non-conductor, and will be useful where its consistence is not affected by temperature. All the houses in marshy districts ought to be constructed on the principle above-mentioned, and raised as high as they can to be consistent with convenience, as this is the most effectual method of insulating the whole members of a household. Some of the semi-barbarous tribes of Panama construct their dwellings in the trees. This practice must have arisen from an experimental knowledge of the utility of the practice. It is of great importance that the barracks of soldiers in pestilential countries be well raised above the ground, and the under floor never occupied.

By a practice sometimes followed in hot countries, a marsh, or, at all events, its equivalent, is formed by the people in their own houses. For the purpose of reducing the temperature, they water the floors to enjoy the agreeable cooling of the evaporation. In a paper in the *Edinburgh Medical and Surgical Journal*, for 1826,* on the fever which prevailed in New Brunswick about the above date, Dr. Boyle, after describing the topography, the atmospherical phenomena, both as regards tempera-

* Vol. i. p. 326.

ture and moisture, also the most prevalent disease, the season of their most frequent occurrence, and the localities most visited by the disease, states:*—"Among other circumstances influencing the health of troops in quarters, none are so frequent as those depending on the nature of their accommodation. The barracks formerly occupied by those stationed in St. John's had long fallen into complete decay; and, besides the obvious objection to one of them, whose situation exposed it to inundations at every tide, they scarcely afforded shelter from the inclemency of the weather. Since these have been abandoned, and the soldiers removed to a spacious building newly erected, where they enjoy greater comfort of every kind, cases of this fever, and of every other acute disease, are far less frequent than formerly. The introduction of open fire-places, instead of cast-iron stoves, whereby the pernicious effects of high temperature are effectually guarded against, while a free circulation of pure air (a circumstance of no small importance in an apartment containing thirty or forty persons) is also provided for, must likewise be considered a very great improvement.

"I may, perhaps, be allowed to take this opportunity of noticing a practice, sometimes followed in warm climates, of frequently drenching the floors with water, which is extremely injurious to the health of soldiers. When the floors are made with a mixture of lime and clay, as is not unfrequently the case in the Mediterranean, or paved with tiles, much of the water soaks through them, and they long retain the moisture; and, under a current of

* Page 7.

air, they afford a constant evaporation, and fill the apartment with humidity. This I had more particularly an opportunity of observing in Sicily, in barracks which had been recently constructed in the isthmus of Melazze, on a clean, dry beach, about 200 yards from the sea, having a free exposure to the west, and being in a situation in every respect well chosen. Cold and moisture were here conjoined, and the soldiers experienced vicissitudes of heat as often as they sought shelter in them from the oppressive influence of a powerful sun, generally placing themselves, half naked, in the strongest current of air. I am aware that the situation alluded to may be deemed unhealthy for other reasons, but I can by no means allow that the sickness which prevailed among the troops who occupied those barracks was occasioned by any other exhalations from the *soil* than that of *moisture alone*. If soldiers in Britain or New Brunswick sleep on such floors badly protected, sickness will almost inevitably follow, and, it is imagined, there would be little doubt entertained as to the cause."

It produces no surprise to find that barracks so situated as those stationed at St. John's should be found unhealthy. Apart altogether from theory or philosophy, it is well known to common observation that places exposed to inundations, and consequent dampness, are inimical to health. The authorities who placed a residence for human beings in such a place have not been in the possession of the most ordinary intelligence. It was just what might have been expected, that the soldiers, when removed to a drier, and more roomy, and otherwise better conditioned residence, should be comfortable and healthy. Besides receiving a better supply of fresh air, the open fire-place would secure a drier condition of this element if it were dry out of doors. The heat of the stove would cause vapour to arise during the cooking operations which are generally done in the sitting apartment of a numerous class of the community. This vapour, with that which is emitted from the lungs during respiration, will cause the air of the close apartment, with the stove, to be in a moist condition, especially if a number of individuals be in the same room. So long as the apartment is at an elevated temperature, the vapour will do little harm; but when the room becomes cooled, the dampness will then cause a low electric tension.

Living on the surface in many places where it is damp, and where there is active evaporation, has been demonstrated to be sufficiently prejudicial to health, but it is much more so where the habitation is completely under the surface of the earth. Allusion is made to a practice very generally followed by the inhabitants of the Crimea, of living under the surface altogether, and there is, consequent on this practice, a large amount of ill health. The following is from a writer in the *Medical Times and Gazette*, No. 353:—

"The Russian medical officers evidently consider remittent fevers to be the endemic of the Crimea, and this is the principal disease from which the Tartar inhabitants chiefly suffer, and likewise the Crimean and French intendanté and other employés in the service of the Russian nobility on the south coast. This natural tendency to the endemic of the climate appears to have been further aggravated by the system of underground hutting adopted in the Russian camp—the same system, in fact, in use with the Turks, and to a great extent by the Tartars, which, whatever advantages it may possess in affording shelter and protection against the extreme cold of a Crimean winter, is deficient in those sanitary conditions, dryness and ventilation, so essential to health. Baron Larrey, alluding to the subject upwards of fifty years since, stated that the system of underground hutting adopted by the Turks was productive of a malignant kind of fever. The same exciting cause appears to have operated in some degree in producing disease of an allied nature, in the French and Sardinian armies, during the late campaign in the Crimea; and it is impossible to observe the abodes of the native Tartars without being led to the conviction, that the low form of intermittent fever from which they invariably suffer at certain periods of the year, must be in a great measure produced by the vast absorption of damp and moisture, combined with a thorough want of ventilation which exists in a potent form in these earth-clad habitations."

The above mentioned mode of underground hutting is well fitted to cause all the mischiefs referred to by the medical officers mentioned in this extract. The floor, the walls, and the roof will cause a continuous abstraction of nervous power, by the absorption of the electricity which radiates from the body, and will be continually exacting more than the system can spare. The walls of these graves for living beings will have a security for being wet by the percolation of the water from the surface during the rainy season, and also of direct inundations when the rains are copious, thus adding materials for the greater virulence of the diseases arising from these pestiferous excavations. There are no grounds of surprise at the frequent occurrence of remittent and intermittent fevers in circumstances which are so well calculated to reduce the nervous energies. It also appears that this form of under-surface dwelling has been long in use amongst the Turks and Tartars; and although malignant fevers frequently rage amongst them, they still continue to retain their fathers' habitations. The low form of intermittent fever by which the inhabitants so frequently suffer has, without any connexion with theory, been attributed to their living in these under-ground dwellings. The malignant form of fever observed by Baron Larrey may have been produced by the combined operation of evaporation on the surface, and that from the clayey walls of these caves.

The wetting of the floors is another source of mischief in warm climates; and from no other cause than the consequent evaporation which must necessarily result. Dr. Boyle considered that mere moisture was the only agency which was influential in producing the sickness in the barracks in Sicily. If barracks were in the midst of the desert, where Dr. Livingstone and his comrades could sleep in the open air with the greatest impunity, and if the floors were drenched with water, and afterwards the soldiers lay down on them, the same mischiefs would arise there as arose in the barracks on the isthmus of Melazzo. This would not occur from the mere effect which would arise from the contact of the people with the moisture, but rather from the negative effect produced on the floor by the exacting of the electricity, by which it produces the process of evaporation. Dr. Boyle considers that the causes recognised as those which produce disease are "obscure and of doubtful existence;" but, in the case of the barracks, the sickness depended on *moisture alone.*

Marshes have a permanently degenerating effect on the people who live so near them as to be always under their influence. They have not the robust, healthy appearance of people in other and drier parts of the country. Dr. Watson states that "in the West Indies the inhabitants of places much infected with the peculiar miasmata are feeble, and sickly, and short-lived." And again, a little further on, the Doctor says, "Independently of the paroxysm of ague, there is ample evidence to show the injurious influence of the malarious districts upon the general health. In this country such effects are not much seen; but in places where the malaria is more constantly and abundantly present, the race of the inhabitants deteriorates. Their stature is small, their complexion sallow and yellowish; they are prematurely old and wrinkled; even the children early acquire an aged aspect; and the spirits and intellects of those who dwell in these unhealthy spots, are low and feeble, and partake of the degeneration of their bodily qualities."

How can people be otherwise than sickly, and weak, and never well, when they are continually operated upon by a power which strikes so uninterruptedly at such a vital part as the nervous system? How can all the functions of the vital operations go on in marshy situations, when there is, in continual operation against them, a power acting unfavourably upon the initiatory vital organism, which is required to initiate every vital manifestation in the animal system? A power, directed against this, is against vitality itself; and it is upon this, the most important portion of the animal economy, that evils so formidable are generally directed.

In a report of an epidemic fever which prevailed in several provinces in India, in the years 1809, 1810, 1811,* by a committee of three medical men, certain facts are given which, they believe, have had some connexion with the cause of the fever. They have observed that whenever they found a high and dry situation, it was always healthy, and that, on the contrary, whenever they found a low damp situation it was unhealthy, and the seat of disease. It was also found that, in proportion to the amount of heat and moisture in a locality, so was it insalubrious. This is brought out very clearly in their report. Near the end they remark, "We have now seen that three great remote causes have been assigned for remittent and intermittent fever; all of which we conceive have contributed to produce the calamity which has proved so fatal in this province. But marshy situations do not appear of themselves to be sufficient to render such affections epidemic: to produce this effect, there is required the superagency of a close, moist, and sultry heat, and imperfect ventilation. Hence it is, that in common years there is not produced, in many of the low situations, a miasma of sufficient malignity to excite the general disease; because, in such cases, the exhalation of superfluous

* Ed. Med. and Surg. Journal, 1817.

moisture takes place, during the cold months of December and January, when they are comparatively innocent: but rains falling out of season, and in great abundance, at periods when the weather had become hot, and when there was so distressing and unnatural a deficiency of free ventilation in the atmosphere, occasioned evaporation of a very different nature, and which, we conceive, became a positive source of mischief, by bringing on that corrupt and stagnant state of the air, which is ever closely connected with the decay or decomposition of vegetable matter."

"Nearly a similar departure from the common course of seasons took place in the Tinnevelly province, in the year 1757, as is mentioned by Mr. Orme, in his 'History of Hindostan,' and that it was followed by a like calamity. He tells us, that in the month of March the south-west monsoon was so violent as to break completely over the Western Ghauts, and descend in vast floods into the Coromandel side of the Peninsula, where the rain fell without intermission for two days—destroying crops just ready to be cut—sweeping away many of the inhabitants—and ultimately, by creating a powerful evaporation during a sultry heat, producing an epidemic disease very fatal in its consequences."

These gentlemen, so far back as forty years ago, had doubts as to the agency of exhalation from marshes, separate from evaporation as a cause of fever. In the above extract, they consider that the evils of the marsh depend greatly on the mere evaporation. During the cold months of December and January, the evaporation was comparatively innocent. The exhalations of moisture from the earth, during cold months, do not cause such a variation of the electric tension as to produce such a negative condition of the earth as when the weather is warm, and the evaporation copious, which takes place after the falling of the rains. The moisture thus produced was considered by them to be the positive source of mischief. These gentlemen could not disassociate the effects of evaporation, and the decomposition of animal and vegetable matter, although little could be discovered either of vegetable or animal matter to produce the decomposition. The fatal consequences narrated in the last paragraph—the sweeping away of the inhabitants—are attributed to the powerful evaporation and the sultry heat.

Not only does the human species suffer from intermittents in marshy districts, but the lower animals also share in the ills arising from the marsh. Horses are said not to suffer so much as other animals. This peculiarity in favour of the horse is attributed to his passing the most part of his time on his feet. The horse is less frequently than his master in the fields after nightfall, and escapes the aggravated insalubrity of this portion of the twenty-four hours. He has a pretty thick hoof of non-conducting composition, which will, in a great measure, protect his vital electricity from escaping in that direction; and the thick coating of hair which covers his skin, will tend to prevent escape from the surface of his body. However, when he is laid down on his bed, which may be wet, he does not enjoy the same insulating circumstances, and may, in this way, be affected with the disease.

Dogs are said to be more subject to ague than horses; and it is not much to be wondered at, as they are more associated with their masters in their evening exposures, and frequently lie on the ground, and, when on their feet, they have not the protecting provision of the hoof like the horse.

In another part of the report mentioned above, the writers mention that the cattle suffered very much, but only from the excessive rains. The organization of men and of the lower animals is nearly alike, and in so far as the provision for vitality is concerned they are the same, and it is reasonable to expect that they will suffer from the same malign influences. "Mr. Peter (Collector of the Madura and Dindigul districts) informs us, that many thousands of cattle have died in the different divisions under his management, since the epidemic first commenced, as much, we are inclined to think, in consequence of the unnatural state of the air, as from a scarcity of hands to feed, and to take care of them.

"In Tinnevelly, we understand from Mr. Hepburn, that not fewer than 44,273 bullocks have died since the beginning of February last; not so much from any particular disease, *as from an excess of moisture in the air*, and a want of people to take care of them."

By the unnatural state of the air is meant the great wetness of it; and the scarcity of the hands to feed and to take care of the cattle, arose from the virulent fever that cut down so many of the people during the great rains, which were hurtful alike to man and animals. The wetness could be hurtful in no other way than by producing a necessity for evaporation which would cause an exaction of electric fluid from the earth, leaving it in a comparatively low state of electric tension, which would present a favourable condition for abstracting nervous power both from man and the lower animals.

Domestic fowls are also occasionally affected with this complaint. This has been observed by their drawing near a fire to become heated while shivering in the cold stage, and they remain close to the heat till the paroxysm passes off. This class of animals are well protected in their bodies, as feathers are a bad conductor of electricity; but their feet are not so protected, and being in contact with the ground, may, in this way, part with their nervous power by the good conducting property of the negative ground, with which they are so much in contact.

Seeing that the fact is so notorious, that intermittent fever is only found in the vicinity of swamps, and that swamps are universally looked upon as the cause of ague, it would be of importance for people who live near them, either to remove from them, or remove the water from the swamps; or, if both be impracticable, it will evidently be most desirable to adopt the best measures of protection from the deleterious effects of the marsh. In those parts of the world where marshes abound, the surface is so flat that the marsh is produced, because the water which is precipitated from the clouds cannot run off. There are not at all times hills or rising grounds to form a refuge from the pestiferous plain, but, inasmuch as nature has not provided this refuge, an artificial provision might be made to escape from the evil influences. The highest available ground near a marsh ought to be selected for a habitation, and the surface around kept as dry as possible; and the ground floor kept unoccupied. Or, as has been already mentioned as having been done in marshy places, the houses raised on stakes of wood. The suggestions here made, and those in a former part of the treatise about the necessity of a proper construction of houses, are not given on gratuitous hypotheses, but on grounds supported on sound philosophical principles, and, above all, they are established by practical results. There are no measures of so much importance to the hapless inhabitants of these unwholesome regions as those which can ward off such a formidable evil as the one which operates so unfavourably and so continuously on the very vitals of the people.

CHAPTER XII.

HOW FAR VARIATIONS OF ELECTRIC TENSION OPERATE IN PRODUCING DISEASE IN TEMPERATE CLIMATES.

It is not in the warm regions of the east and west alone that electric variations act in causing disease. In the torrid portions of the earth, there are manifestations of violent extremes, which at once arrest the attention. There are the great fluctuations of temperature, the long droughts, the tornadoes, and the floods, and the sudden inroads of pestilential disease. These sudden and marked manifestations point more clearly to the agency which causes them, than the more feeble exhibitions of cooler situations; but, even here, sound teaching will be available to all that can read nature in its own book. This book, in the equatorial regions of the earth, is printed in large type, in prominent characters, and is much more easily deciphered than the small and rather obscure characters which are displayed in that portion of the book which relates to the temperate zone. But, small and indistinct as these characters are found, yet careful study and observation may make them somewhat plain and comprehensible. The most marked of these lessons which are taught in nature, in the temperate regions, in so far as diseases of the body are concerned, is in those portions of our country where swamps abound with consequent and prevailing sickness. There the cause can be traced from its effects. Although allusion has already been made to the manner in which marshes act in producing disease, we may again recur to the subject for the sake of illustration. Where swamps exist, and, in their immediate vicinity, there is prevailing and persisting intermittent fever, there is plainly a connexion between the swamps and the fever. This will appear more clearly when alterations in the circumstances of the locality affect its salubrity. When the swamps are drained and converted into fertile fields, the disease disappears, and the neighbourhood is converted from a sickly to a healthy state. The question, therefore, as to the cause of this prevailing disease is confined within a narrow compass. Whilst the water remained in the swamp, there was a constantly attending fever; but when the water is taken away, and nothing but the water, so also is the fever. Then there is an evident connexion between the presence of the water in the swamp and the cause of the fever. Now, there is water in our rivers, in our lakes, in our seas; and notwithstanding the large collections of this element in all regions of the earth, yet no one in the possession of sound sense would suspect that water in these situations and in such conditions could produce fever. But, as a general rule, wherever swamps are found, from which there is copious evaporation, there is also found unhealthiness. We find, then, that the swamp, as a swamp, produces this fever; but separate the water from the soil, or seal it up in ice, and the disease disappears. This has been demonstrated in various localities, in this as well as in other countries. Some of the swampy grounds in the fenny counties of England have been drained, and the disease has left along with the water which constituted the swamp. There is still an important element to consider in connexion with the swamp; and this is heat. In order to analyse more closely the circumstances connected with the swamp and the fever, and how far water is connected with the swamp and the cause of disease, we may inquire whether the swamp retains its disease-begetting power when this element is withdrawn. It is found that the swamp produces no fever when it is completely frozen over. It becomes as salubrious as any other part of the country when its waters are converted into ice. We find, then, that when water is taken from the swamp, and when the heat is withdrawn, the swamp is healthy. It is found, moreover, that when the swamp contains as much water as floods it all over, and converts it into a temporary lake, the health of those living near it does not suffer to the same degree as at another time; but when the swamp is nearly dry, or when it makes a near approach to it, the inhabitants near it suffer most.

Let us examine, then, if heat taken by itself can produce this fever which is attributed to the swamps. In those places of the world where swamps are unknown, and where the water which produces them is in very small quantity, and where heat is in its most concentrated form, there is no fever. In the desert, where the sandy soil is always hot and dry, there is not intermittent or any other form of fever. There, in the midst of heat, in its greatest intensity, there is the absence of fever. Then what element is yet left for our consideration, that we may discover the "origo mali," to understand which has hitherto defied our best efforts? The soil, the water, and the heat have been separately questioned, and, in their separate condition, neither of them can be blamed. When taken conjointly, however, they are found to be injurious. We have seen that the operation of heat on the dry land, as in the desert, has no hurtful influence on any one who is placed thereon; but let it be transferred to sand that has been saturated with water, having the subsoil wet to some depth, and operated on by heat, as in the pestiferous plains of Walcheren, and the effect will be quite the reverse. There is here an operation that has not yet been brought to account, viz., the effect of the process of evaporation on the wet soil. It is indispensable for the success of this process that heat be present; and the larger the quantity, the more speedy and effectual will be the operation of evaporation. If there were a continuous supply of heat, and in such quantity as is supplied by the sun during the day, the evaporation would do no injury, as there is then a greater radiation of heat from the sun than is required for supporting the process of evaporation, and some also to spare to supplement the heat of the animals that are placed on the soil. It is the alternate heating and cooling of the surface which does the injury. During the day, the earth and the animal bodies there situated are kept in a comparatively positive condition. When, however, the sun is absent, the earth retains for some time its heat, and gives off its electricity by continuing the evaporation, and the soil becomes more and more negative until the morning, when it will be most negative, and the abstraction from the animal body will be greatest, and the injury most severe. Hence, in swampy districts, the liability to be seized with fever will be greatest in the morning, before sunrise. The moist earth continues to have a great capacity for heat to continue the evaporation; and, when it has no supply from the sun, it draws it from those animals that are situated upon that portion of it which is in this negative condition. The animal body will, therefore, suffer an abstraction of electricity, which has been demonstrated to be nervous power; and hence the diseases which depend on lesions of this system. In this country there is no desert, and very little swamp; but we are occasionally deluged with rain. How is it, then, that, at these times, we do not suffer from the activity of the evaporation? In this country the water does not lie so long on the surface as to allow a large quantity of the rain to be carried up by evaporation, as the agricultural and other draining operations so speedily carry off the water after it falls that little is left to require this process, and little injury is sustained. The animal body employs a method of acquiring heat, which yields a much larger quantity than is absolutely required. The overplus is given off by radiation, and, in any situation where the surface is tolerably dry, there will be no injurious abstraction from a healthy individual, as there is not the high temperature to cause the rapid evaporation of hotter countries.

But, independently of general and wide-spread operating influences which abstract the electricity from the human body, there are others which are confined to a limited locality, such as the ordinary habitation of a family. Every medical man who has had an opportunity of practising among the people in the common walks of life, or among servants in underground kitchens of people in better condition, may have observed, that people living in houses with stone floors are unwell much more frequently than those who occupy houses with floors of wood. These stone floors exert an abstracting power which operates detrimentally on those who reside in houses with such a provision. During the greater part of the day, the feet either have no covering or are very imperfectly protected, though in contact with the stones. The stones are good conductors of electricity, and will abstract it from the human body, and the abstraction will be borne differently by different individuals. The robust and the strong, whose vital organs and their operations continue in all their integrity, will be able to bear the abstracting power with comparative impunity, and may continue well for a long time notwithstanding the malign instrumentality that is operating against them; while the delicate and feeble, whose vital energies are weak and languid, and whose strength may be reduced to that condition which borders on disease, will require only the abstracting power to begin in order to produce derangement and disease.

The author has often observed the verification of this fact in houses of the kind above described, occupied by tradesmen who were closely confined to apartments with stone floors. This class of society generally occupy houses with two apartments, one of which is appropriated to the general uses of the family; the other is usually reserved for the more particular occurrences in the family history. The one most in use has generally a stone floor, the other is made of timber. The author knew a family of this class who occupied a house of this description. The members of it were frequently affected with illness. They were scarcely ever well. By recommendation they went to a house with wooden floors, where they became speedily well, and, so long as they continued in this habitation, they required no medical aid. For some reason or other, they were obliged to go again to a house with a stone floor, when their former tendency to become ill returned, and so far as is known to the author, they continued so as long as they remained in it.

In another case a house was occupied by three individuals, and it was provided with this kind of floor in that apartment which was most occupied by the family. The people had remained in it for some years, and during that period they suffered very much from various ailments. The author at once attributed this tendency to become unwell to the abstracting power of the stone floor. The proprietor of the house having been induced to place a wooden floor over the stones, the health of the inmates has been better ever since, and they are now satisfied that the favourable change has taken place in consequence of the super-position of timber on the stone. The reason of this difference between stone and wood, when used as floors, is very apparent on these principles. The stones are much better conductors of electricity than wood. There is little need to multiply examples of this mischievous peculiarity of stone floors, as facts of the same kind must frequently pass under the observation of any one who has an opportunity of looking at them as they pass before him.

There are other peculiarities in the habitations of the people which act injuriously on their health, but are not so prominent, and on this account are less worthy of remark. It is in the open air, amidst the alterations of temperature and moisture, that the most powerful agency for evil exists, and the evil agency operates in these latitudes as well as in those that are warmer. But, as has been already observed, it is in the torrid zone, where the rays of the sun are sent most plentifully down and in the most direct manner, that this element operates with most power. It is by electric power that the water of rivers and lakes is dried up, and this element, in thus carrying up the water, is itself carried up, and becomes accumulated in the upper regions of the air, whence it darts to the earth in violent thunderstorms. In the temperate regions of the earth, the same kind of action is going on, but in a much less vigorous manner. The same power is in operation, but in a less observed form. The rivers and lakes are not dried up, but there is an alternate wetting and drying of the earth in a much more moderate measure; and in a proportionably moderate manner does it alter the electric tension of the earth. This moderate alteration of the electric tension of the earth will act with corresponding moderation on the animals found on the portion of the earth thus acted on. It is in this manner that we must view the operation of these alterations in this country; and these alterations will be prejudicial in proportion to the amount of water to be raised and to the quantity of heat necessary to raise it, and the nature of the locality from which the vapour is to be raised. In accordance with these views, other influences out of consideration, a given place will be healthy or otherwise, just in proportion to the wetness or dryness of the situation. Elevation—as has been demonstrated—will on this account have a favourable effect in any situation to make it healthy. It will be easily understood that the more elevated a situation is, the greater are the facilities presented for the precipitation and percolation of the water that may fall on it.

Independently of the abstractions which are produced by contact with the soil, there are other kinds of exposure which cause mischievous results. A very common cause of many complaints is the getting of the vestments wet. A person has been exposed to a shower of rain, and sits inactive till his clothes dry on him. Now, supposing that the individual has just sufficient elimination of vital electricity to supply nervous currents, and none to spare in radiation, to change the water in his clothes to vapour; every particle of heat that is abstracted by evaporation will be less or more injurious to him. A case where the vital powers begin to wane, as in a person advancing in years, or one worn down by dissipation, in whom the development of heat would be no more than what is just required for vital action, would on this principle be much injured by being placed in such circumstances. We may suppose a person in an opposite condition of the body exposed to influences of this nature. In this case there is a great amount of bodily vigour, and the vital operations are in the utmost integrity. He engages in an undertaking which requires severe muscular exertion: he continues his labour for some hours together, and, just before he takes his meal, sits down on the grass in a state of perspiration, exposed to a shower of rain, and continues for some time wet. These are circumstances which, on this principle, would be very mischievous. Now, what phenomena may be supposed to be developed in a case so circumstanced? For some time after the commencement of the exertion, digestion, assimilation, and respiration would be active; and decomposition going vigorously on during these processes, there would be a large disengagement of vital electricity to communicate power to the nervous system for supporting the violent action. Supposing the person in possession of a good meal, before beginning his labour, digestion and assimilation would continue during the first two or three hours of exertion; but, on the suspension of these processes, the electricity from this source will cease, and there would remain that from respiration alone. Ultimately, in a state of perspiration, and from a sense of exhaustion, he is induced to rest on the grass, and gets wetted with a shower of rain. The respiration now becomes slower; there is consequently less evolution of heat, and still a great demand for it. The evaporation of the perspiration and of the rain causes a greatly increased amount of radiation of electricity from the body, and the ground on which he lies is an excellent conductor, and copiously withdraws the vital electricity in that direction. After exposure for some time to such influences as these, it may follow that the abstraction of vital electricity may have exceeded the point which is essential for the integrity of the vital operations and functions, and the power of the nervous forces may thus be insufficient to elaborate from the blood those secretions and excretions which are indispensable to sound health, the blood thus becoming contaminated with those elements which ought to have been deposited in the body, as well as those that ought to have been thrown out of it: thus producing derangements and diseases depending on such changes.

Between the old and infirm, and the young and vigorous, there are many degrees of predisposition and susceptibility to diseases; and such individuals will be injuriously affected in proportion to the power of the abstracting agency which may be operating against them. There will be no difficulty, on this principle, in understanding how the susceptible and predisposed are the most ready to suffer from pestilential disease. In diseases and derangement, up to a certain point, of the assimilating and respiratory organs, when those processes are interrupted which contribute vital electricity, it will follow that all the vital actions depending on a definite and proper supply of nervous power, will be inadequately and imperfectly performed. Suppose an individual, with just as much nervous power as is necessary to provide the exact amount of electricity that is required for the exigencies of the system, and nothing more, exposed to a powerful abstracting influence, such as copious evaporation, then would the secretions and excretions be imperfectly elaborated from the blood, and thence would arise diseases, depending on contamination of the fluids of the body. It is in tropical regions that these causes operate most powerfully, and it is there that pestilential diseases cut down the human family in great numbers. Finding that full integrity of the nervous power is indispensable, it will be the first care of the prudent to prevent its escape. That kind of clothing, then, which confines most effectually the caloric which is eliminated during the vital operations, is evidently the best. Many of the diseases to which the poor are liable, are attributable to imperfect clothing.

Nature has exercised great care in adopting means to prevent the escape of electricity from the animal portion of creation. In those cases where the hair is not given in sufficient quantity to accomplish this purpose, a large amount of fatty matter is deposited in the cellular substance, immediately under the skin, as in the case of the hog and other animals. The infant of our own species, too, in whom vital electricity is of so much importance, is well supplied with this protecting provision, as all the salient points in the frame of the little one are buried in its own fat, displaying that wisdom in which there is no imperfection. It seems to be a contrivance, at this early period of human existence, to provide for the possible neglect of unnatural and improvident parents. It is sometimes melancholy to observe the fatuity of some parents in fashionable life, where the poor little creature is often exposed to the chilling effects of a northern blast, with the extremities and other portions of its person half covered, and the countenance exhibiting a livid aspect, eloquently appealing to the sympathies of the passer-by, but vainly to the parent who is the slave of fashion, and who at all hazards must have her boy dressed *à la mode*. There is a persuasion, also, in some quarters, that children are improved by exposure; but, in the case of most children, and especially delicate children, who are less favourably provided for by nature, this hardening process just hardens them for the grave.

Next in importance to vestments for the body, are comfortable houses for habitations. Care, therefore, in the construction of houses, and prudence in the selection of situations for building them, are of great importance for protecting the system against abstracting influences. The houses of the poor, in many situations, are most injurious to the general health of the inmates; the lowest and most humid part of a town is usually occupied by this portion of the community, close to a stream or river, exposed to occasional inundations, which leave the houses miserably cold and damp,—receptacles primed with the elements of disease and death. It is in localities such as this, that pestilential diseases first make their appearance, and they continue to linger there, after they have left more favoured situations.

Some towns are so situated that nearly the whole of the inhabitants are placed in an unfavourable position in regard to salubrity. There is a good illustration of this in the case of Croydon, a small town in the county of Surrey. Its situation is low, and nearly surrounded with hills. The river Waden takes its rise a short distance above it. The following account of an epidemic is from a newspaper paragraph, dated 11th February, 1853:*—

"It is gratifying to be enabled to state that the mortality has very materially decreased during the week, the total number of deaths for the whole district being eighteen. Of this number, thirteen fatal cases were in Croydon; but it appears from the report that only four of these are cases of fever. There appears to be very little doubt that the excessive wet weather during the last few months has

* Scottish Guardian.

been the principal cause of the epidemic, and a very singular prophecy has been verified, with regard to a spring called the Bourne, which rises a few miles from Croydon. Two of the old historians of Croydon mention, with reference to this spring, that, when the Bourne rises, the people of Croydon may look out for death and pestilence. The spring is frequently quiescent for several years, the general period being seven between one rising and another; and up to the present year, nine years have elapsed since the Bourne has overflowed. This year, however, it has risen higher than ever, and has flooded the country in its course to a greater extent than ever was known. It may be said, that the past epidemic has rather singularly fulfilled the ancient prophecy."

There is here no marsh to produce the malaria, to cause the fever. There is merely the inundation which overflowed the habitations of the people; and then followed the fever. Besides the inundation, there were long-continued rains which would completely saturate the soil all around the town, and the flooding of the houses was the greatest evil that befel them. The floors and the walls, their beds, and every part of their dwelling, would be impregnated with water. What an array of evil influences besetting the poor people in their own houses! The very refuge from the damp and cold without, converted into coldness and dampness within,—fit ministration to the grim messenger of death! This was the source of the fever. There was here continually operating a powerfully abstracting agency. The water in the floor and the walls, and it may have also been in the bedclothes, had all to be raised by evaporation; and the heat to produce this was withdrawn from every object around that was warmer than the substance containing the water; and a special draught was made on the human body, which is always at a higher temperature and more positive than the objects around. There was thus operating upon the people this powerfully abstracting agency, which would so reduce the nervous energies as to cause the fever that followed the inundation.

So constantly has disease followed the overflowing of this stream, that it is not only traditionally known to the inhabitants, but it has also been the subject of history. Eighteen fatal cases in a week was a large mortality for a small town like Croydon, proving how malignant must have been the cause that produced such an amount of evil.

The ordinary diseases that occur independently of general causes, may all have their origin from the operation of the same agency, on an individual case. There are numerous methods by which abstraction of nervous power may take place, and produce diseases which are attributed to having caught cold. The circumstances in which persons are placed, by which they might be brought under abstracting influences, are innumerable. Insufficient clothing, getting the clothes wetted, sitting inactive in currents of cold damp air, coming out of a warm room in a state of perspiration, especially after being engaged in dancing. This latter exercise is both violent and exciting, and necessarily attended with a great exhaustion of nervous energy. The perspiration in the dress, in being evaporated, would still more abstract the electricity from the body.

These are examples of the numerous methods by which evil agencies operate on people to cause disease. Indeed, the greater number of those complaints which arise from internal causes, is attributable to the abstraction of nervous power.

On the principle that nervous energy is withdrawn by these instrumentalities, the proximate cause of inflammations may arise in the following manner:—An abstraction of nervous power is made from the whole nervous system by a good conducting medium, such as the sudden application of moist air to the surface of the body, getting drenched with a shower of rain, lying asleep on the earth, especially at night, sitting in a current of cold air when heated, &c. The whole nervous system will, in this way, suffer an abstraction of electric force, by which its power will be weakened, and an impression will be made on the weakest individual, and in the weakest part of his system. A healthy, vigorous frame will withstand many unfavourable influences, but the predisposed will most readily suffer. The commencing departure from health may occur in the following manner:—The power of the general nervous system being reduced, the nerves, acting on the capillaries of a particular tissue, will be in a state of enervation, unable to cause the contraction of their walls. There will consequently be an inability to propel their contents, and the walls of the vessels consequently dilate, as they have lost their tonic action, causing a want of balance between the propelling power within and the resisting power without. The resisting power without being overcome, enlargement of the vessel takes place, the heart continues to propel its contents with its usual vigour, and the yielding vessel dilates the more. A large number of these vessels thus yielding will produce the swelling, and the stretching of the vessels will cause the pain in acute inflammation. We may suppose a case of inflammation of the finger. The tissue is here in a confined position. The throbbing which takes place arises from the interruption of the current of the blood, occasioned by the yielding, and consequent dilatation of the capillaries, and their being ultimately plugged up. In a common catarrh, phenomena of a like description may take place. Abstraction of vital electricity may have produced enervation of the capillaries of the mucous membrane of the nasal passages. The walls of these vessels, by diminished contractile power, become unable to resist the force of the current within; and the consequence is, that they yield and dilate—as has been already stated—and the dilatation will constitute the swelling which is found in the mucous membrane, whilst labouring under catarrh. In the stretched condition of the capillaries of the membrane, the mucous exhalents will be closed up, and hinder the exhalation of the secretion, causing the dry condition of this membrane in one stage of this complaint. The relaxed condition in which these vessels are left, on their return to their normal size, will cause them to be made easily re-affected when exposed to the exciting cause. This accounts for the liability to a second attack, which generally attends any individual after first suffering from a complaint. The same predisposition to a future attack will be produced from the same causes after any complaint.

In inflammation of any texture of the body, the same order of events may take place and like results follow, in this most favourable termination, viz., resolution. The other forms of disease, which consist of vitiation of the fluids of the body, and of permanent alteration of structure, might in their outset depend on diminished nervous supply. It is difficult to understand the process of change which occurs in the capillary structure of morbid growths, and the effects on the whole system by a vitiated condition of the blood. This will be best illustrated by the researches of histology.

The meteorological influences which produce these diseases in temperate regions, are not so powerful as they are in hot climates, but they are not the less certain. In place of the burning rays of a vertical sun on a thoroughly wet soil, there are the slanting rays of the sun, half-way up the heavens, beaming on a soil partially wetted. The evaporation will be so slow that the variation of the electric tension will neither be so great nor so sudden as it is in warmer regions. The exaction in temperate climates is therefore made by slow degrees; and the impression on the animal system is so partial, that it can scarcely be felt. That portion of the community labouring under disease is most easily affected by atmospherical vicissitudes. A certain class of patients, especially in warm weather, always complain of an aggravation of their complaints in rainy weather. In the following passage from a review in the *Edinburgh Medical and Surgical Journal* for 1824, of a work by Dr. Edwards, entitled "De l'Influence des Agens Physiques sur la Vie," in which the author states his opinion regarding the influence of dry and moist weather on the human body, the reviewer remarks:—

"It has been shown that, at temperatures below that of warm-blooded animals, the cooling of the body is not affected differently by the driest and moistest condition of the atmosphere. This fact appears incompatible with the different sensations produced by dry and damp air at the same temperature. Dr. Edwards considers the reason to be that dry cold air acts merely on the surface of the skin, while moist air has the peculiar power of exhausting the faculty of producing heat; and he appeals, in support of his opinion, to the different qualities of the sensations produced by each. In dry air, the sensation of cold is superficial, and when the influencing power is intense, it causes rigidity and torpor; but in moist air, the sensation is deep-seated."

In the above extract, Dr. Edwards is represented as contrasting the effects of moist and dry air on the human body. He considers that the moist air makes a deeper impression upon the body than the dry air. If Dr. Edwards had known to view heat and electricity as identical, the phenomena produced on the body by moist and dry air would have been more easily understood. Heat and electricity are just manifestations of the same element. Cold, dry air, although to a certain extent favouring the escape of electricity from the body, has a constringing effect on the cutaneous surface, which seems to limit the amount withdrawn. It is only the coldness which has the exacting property, as the air in its dry state is not a good conductor of electricity. Dr. Edwards states, that when cold "is intense it causes rigidity and torpor." The moist air, on the contrary, has the "peculiar power of exhausting the faculty of producing heat," and the sensation of moist air is deep-seated. The moist air has the power of withdrawing the nervous power from the organs that produce nervous power — from the organs of respiration and assimilation which are employed in disengaging from the bodies presented to them the very element which moist air so copiously withdraws —so that, in "exhausting the faculty of producing heat," the faculty of producing nervous power is exhausted. The following may be the mode in which this effect is produced. In a moist state, the air, or more correctly the moisture in the air, is a good conductor of electricity; and at all temperatures, either in the temperate or torrid zone, which are below animal heat, it must be injurious. The heat of the animal is rarely exceeded by that of the air; and this air, though laden with moisture, if acted on by a vertical sun, will neutralise the effects it would have on the animal frame, by keeping up the temperature in spite of the conducting influence of the moisture in the air. It is at night, when the sun ceases to shine, and the temperature of the earth and air becomes lower, and when they at the same time continue charged with a like amount of moisture, that the conducting influence operates so prejudicially on the animal body, exacting more powerfully its inbred electricity, as it is always positive considered relatively to the bodies around it. The disposition of electricity always to find its equilibrium will also produce this at the expense of the animal body.

Latterly, inunction with oil has been recommended as a remedial measure. This application has been introduced, because it has long been observed, that the people engaged in woollen factories enjoyed superior health in consequence of the great quantity of oil which is used in these establishments. Mr. Thomson, of Perth, has given the result of his observations on the influence of woollen manufactures on the health of those employed in them. It has already been pointed out that the workers in an oil establishment in India remained unaffected with fever, whilst the people outside the establishment were carried off in great numbers. It is to the non-conducting properties of the oil that all the good effects may be attributed, which arise to workers in wool establishments in this country, as well as to those in the oil establishment, which was mentioned as being in India. Dr. Simpson has made some observations on this subject, and from these he has drawn up the following propositions. Mr. Thomson quotes them in his paper:*—

"'1. That the operatives in the wool factories are a healthy class, and that the oils among which they work undoubtedly contribute to the promotion of good health.

"'2. That the oils in the factories pass into the system, chiefly by the *skin*, and perhaps by *inhalation* also, thereby improving the constitution.

"'3. That oils rubbed into the skin, or absorbed by bathing, are important remedies for arresting or averting diseases, arising from defective nutrition.

"'4. That singular exemption from epidemic influence seems to belong to all those operative classes much engaged among oils.

* Ed. Med. Journal, June, 1858.

"'5. That external oil-inunction is a cleanly process, and deserves, at least as an adjuvant, to be actively used for the prevention and treatment of scrofula, consumption,' &c.

"These propositions appear so valuable that I am anxious to strengthen the proof regarding them, by the following statements and statistical tables:—

"There is nothing new under the sun. The virtues of oil, externally applied to the human body, are noticed as early as the dawn of human history. In the Bible oil is spoken of as applied to the consecration of the Hebrew priesthood, and for other holy uses, as a type of Divine grace and goodness. It is also praised as an article of value, a luxury in the same category with one of man's chief blessings:— 'Wine that maketh the heart glad; and oil that maketh his face to shine.' From the siege of Troy to the fall of Rome, many of the classic poets are found to make reference to oil-inunction. The warrior when he went to the field, the wrestler preparing for the arena, was strengthened by oil friction and bathing—'non olivum vitat'—and the gods and goddesses anointed with fragrant oils to grace the festivals and ambrosial feasts of Olympus. Nor have the philosophers been silent upon this. Seneca practised oil-bathing; Pliny says, 'The human body receives vigour and strength from every kind of oil.' Democritus, when asked upon the subject of health and long life, answered with a common maxim of the day, similar to the Scripture expression already quoted, 'Apply *wine within* and *oil without*.' And one of our own sages—the brightest in what may be called *our* Augustan age—Lord Bacon, says: '*Beyond every agent for prolonging life, I know not any equal to the* *external application* of oil to the human skin,'—'Ante omnia usum, olei vel olivarum vel amygdali dulcis ad cutem.' Stronger testimony for any remedial agent cannot be gathered anywhere, and it is curious that the moderns should completely have forgotten a substance so highly sanctioned by authority."

And again, "It is quite proverbial among the people, and plain to the workers themselves, that weakly children, in a very few months after entering factories, exhibit a marked improvement in physical appearance. The testimony of the certifying surgeons from Galashiels, Hawick, and Alloa, corroborates this statement. In rural districts, this is notably the case; and in Glasgow and Aberdeen, the contrast betwixt the cotton and wool workers, is attested in favour of the latter by the factory inspectors and certifying surgeons. In Yorkshire, the better classes frequently send the delicate members of their families to the woollen mills for the benefit of their health."

All the benefits above described, as being the result of oil-friction, the inhalation and absorption of oil, are far more satisfactorily accounted for on the principle that it has good non-conducting properties, and it prevents an undue amount of radiation of electricity. One effect of this will be, that the energies of the vital organs will be greater in consequence of the better confinement of the electricity, which supplies nervous energy to the digestive and assimilating organs, thereby enabling them to appropriate more effectually the ingesta which are introduced into the stomach to nourish the body. We find here, that testimony from the remotest antiquity has come down to us, in favour of oil as an external application. The Hebrews, the Trojans, the Greeks, and the Romans, have all sounded its praises; and in these later times, facts accidentally spring up, and arrest our attention, which corroborate the experience of bygone ages. Although the benefits of this application have been long known, yet a rational idea of the *modus operandi* has not been established. Dr. Simpson suspects that it is absorbed by the skin, and by inhalation, and in this manner protection from epidemic influences is communicated by its use. The most effectual method of procuring absorption is to present the oil to the absorbents of the intestinal canal, as this would be the most favourable method of effecting the appropriation of the oil. The fact of the beneficial influence of oil on the health of the workers with it, has been long observed—has become "proverbial among the people." The knowledge of this fact has led to the external use of oil both as a remedy and as a protection from disease. It will require a profuse oiling to be put in the same condition as the workers in these factories, as, besides their skins, their clothes are saturated with it. The circumstance that the oil-workers, all over the country, are found to be a healthy class, and have long been so, establishes the connexion between the operation of the oil on the people, and their superior health. They are not only more free from disease than workers in corresponding factories of other textures, but actually grow more in absolute weight. Dr. Thomson demonstrates this fact by various interesting tables. In one of these he contrasts the weight of students of the Edinburgh University, and that of persons of the same age attending woollen-factories. The following is the table referred to :*—

Ages.	Weight of Students.	Mean Weight of Boys and Girls at Woollen Work.
15	112 lbs.	98 lbs.
16	125.5	$99\frac{1}{2}$
17	133.5	113
18	139	134.5

The difference is largely in favour of the students. The students generally belong to that class of society who can secure plenty of nourishing diet; and as the whole of them do not become pale and careworn by poring over a midnight lamp, as a class they are not subjected to the same wasting exertions as their toil-worn neighbours. There is another consideration in favour of the students, which may not be enjoyed by their more hard-working neighbours, and that is, their better chance to have good clothing. The warm clothing will be a good substitute for the oil, as if it is good enough in quality, and large enough in quantity, it will prevent the escape of electricity equally well.

If the principles here advocated be ultimately recognised to be true philosophy, it will have a particularly important bearing on the question of contagion. It would be very desirable were this question set at rest, as it has been long observed that apprehension and disturbance of the mind predispose to what have hitherto been viewed as infectious diseases. It would be difficult to demonstrate, that the concentrated emanations from the bodies of

* Ed. Med. and Surg. Journ. June, 1858, p. 1090.

patients labouring under fever, are innoxious and inoffensive, as experience has long proved the contrary to be the truth; but they are less influential than is commonly supposed in producing mischief; and fever is almost always dependent on the altered electric conditions of the body. These alterations may be consequent on the circumstances and influences affecting those individuals who may be living in near proximity to patients labouring under fever. For illustration, we may be allowed to suppose a case:—A member of a numerous family becomes affected with fever; the members of this family have the same constitutions, and the same predispositions; they eat at the same board, they dwell in the same house, they are clad, it may be, with the same fabric, and in all things which affect them either morally or physically, they are the same. The house is not so large as to allow the patient to be placed at a distance from the other members, who, conscious of the near proximity of fever, and firm believers in the contagious nature of the disease, are filled with fear and apprehension both for their friends and themselves. They can neither sleep nor eat, because of their sympathies and alarms. The wakefulness tends to exhaust the nervous energy, and by the disturbance and suspension of digestion, the electricity is withheld which might have been evolved had this process been active and continuous; from these causes, also, the nervous system becomes less vigorous, less able to continue the processes of assimilation, secretion, and excretion; the blood becomes vitiated by the elements that ought to have been thrown out; and hence the derangements that may constitute fever.

It has always been held that insufficient ventilation, and the crowding of many persons together in small apartments, have been a prolific source of the spread of epidemic disease, when it has found its way amongst them. That such circumstances should be deleterious, there can be no doubt; but from other causes than the operation of contagious or infectious emanations. The crowding together of a large number in small and ill-ventilated places, causes a vitiation of the air by accumulation of the carbonic acid which is expired: and the inhalation of this adulterated air mars the decomposing operations in the lungs, and thus the blood is left more or less contaminated, by the retention of what ought to have been thrown out; and thus there is a diminution of the development of electricity for the support of vital power. The same necessity which causes the crowding together, will often cause an insufficient supply of nutritious food, and consequent diminution of extrication of vital electricity, during digestion and assimilation, and also attenuation of the composition of the blood from the curtailed supply of the elements of the body. Superadded to these unfavourable circumstances, the floor of the little apartment may be of mud or stone, which, from careless or filthy habits, may be kept constantly wet; a powerful agency is thus created of a detracting nature; the feet, or some other unprotected portion of the body, being kept in contact with the floor, will permit the long-continued action of this good conducting medium, which will withdraw the electricity in larger portions than will be consistent with the healthy performance of the vital functions. It will always be important to protect the body well during sleep from all abstracting influences, as then the operations for elimination of electricity are much less active; respiration and digestion being more slowly performed. Lying on a damp bed will, on this account, be very injurious, as the electricity will be withdrawn from the body to promote the evaporation of the moisture contained in the bed-clothes. Many cases of severe illness can be traced to exposures of this nature.

Facts might be accumulated to an indefinite amount in support of these views, but, as appears to the author, a sufficient number has been adduced to illustrate his propositions. These principles may be applied to many of the other phenomena which appear in the vast field of medical science, but they cannot be grasped at the very threshold of an inquiry. As inquiry and observation progress in the path of true science, facts will ultimately be developed which will enable us to adopt what is true, and reject what is false.

CHAPTER XIII.

OZONE THE RESULT OF THE ACTION OF FREE ELECTRICITY ON THE OXYGEN OF THE AIR, AND A PROOF OF THE ELECTRO-POSITIVE CONDITION OF THE ATMOSPHERE.

A RECENTLY-DISCOVERED chemical body has been supposed to have some connexion with the existence of pestilential disease. This body, called ozone, is admitted to be produced by a combination of oxygen and electricity. Oxygen, as commonly known, has combined with it a large quantity of latent electricity, and has a strong affinity for other bodies; but, when combined with an additional quantity of electricity, its affinity for other bodies seems to be increased, the compound being more powerful as a decomposing agent. In a paper from the *Press* in the *Medical Times*, Professor Schönbein and Messrs. Martignac and De Reve come to the conclusion, from a series of experiments, that ozone is nothing else than a peculiar state of chemical activity impressed upon oxygen by electricity. Most chemists, however, still hesitated to admit the modification of oxygen; but the experiments published in 1852, by Messrs. E. Fremy and Edward Beckerel, seem to have removed all doubts on the subject. Thus "ozone is only a peculiar form of oxygen, produced by electricity,—a change analogous to that which the solar rays bring forth in chlorine, by rendering its affinities more powerful, or to the modifications which are excited by heat in sulphur, phosphorus, and carbon."

There are two methods by which its presence is made known, viz., by its peculiar smell, and its action on iodide of potassium. It is stated in the same paper, that "ozone has a very penetrating odour, resembling that of chlorine mixed with air, or of phosphorus and sulphur in combination." Another means of discovering ozone, is by observing its effects on the iodide of potassium. In the same paper, this is stated to have been done in 1850, by Professor Schönbein:—"He had ascertained that ozone decomposes iodide of potassium, and concluded that the best re-agent for finding out the presence of ozone is starched paper containing a small quantity of the iodide. Paper thus prepared and exposed to the action of the atmosphere, soon revealed the presence of ozone. But it was evident that this singular body could not always be contained in the air in the same proportions, and to study these variations a scale must necessarily be formed." By means of a scale made with the iodide in starch on paper, the daily variations of atmospheric ozone may be ascertained in the same manner as those of the temperature and weight of the air by the thermometer and barometer. Some data are given as the results of observations with this re-agent, showing the quantity of ozone in the morning and evening of each day of the year. Dr. Bœckel remarks, that "during a fog the ozonoscope frequently marks zero, as only a rapid formation of vapours, or their precipitation in rain or snow, is accompanied by a disengagement of electricity. This took place during the last four months of the year, which were frequently foggy. The ozometrical mean of these months has constantly been inferior to that of the remainder of the year." Since the existence of ozone in the air depends on the quantity of electricity in this element, it is to be expected then in foggy and rainy weather there can be but little, as the vapour in the air would carry off the electricity which forms the ozone, or even take it away when formed.

According to Dr. Bœckel, "Malaria always shows itself with the zero of the ozonoscope, and the same takes place when intermittent fever is prevalent."

It would appear that the vapoury condition of the air over marshes is not favourable to the formation of ozone. This is what might be expected *à priori* from the consideration, that the electricity over a marsh is soon carried off and cannot accumulate in any quantity. Ozone ought to be most prevalent when the air is dry; electricity being then in greater abundance than when it is moist. It has been found that when cholera prevails there is an absence of ozone. Dr. Bœckel, of Strasburg, states "that in that town the presence of cholera coincided with the absence of ozone, and that the ozone reappeared as the epidemic decreased." According to Professor Schönbein, "A complete absence of ozone has been remarked in the atmosphere at Berlin, during the invasion of cholera. Dr. Billiard, of Corbigny, is of opinion that the diminution of the ozone in the atmosphere is the first cause of cholera."

The presence or absence of ozone in the air may be regarded as evidence of the presence or absence of electricity. Ozone being absent from the air during cholera, there must be an absence or a diminution of electricity, as in the air there is always oxygen, on which electricity, if free and sufficiently concentrated, will operate.

When the air is dry, this element will be in the greatest degree of concentration; and if there is no conducting agency to diffuse it, an accumulation taking place, it will seize upon the oxygen, combining with it and forming ozone. The principal source of the electricity in the air, is radiation from the earth. In the desert there must be large accumulations of electricity in the air. By merely drawing a non-conducting body through the air, Dr. Livingstone caused a development of electricity, showing that it must have been present in great abundance. In the atmosphere over the arid wilderness, destitute alike of vegetation and moisture, the electricity pouring down in large volumes from a burning sun, being too active to remain dormant, combines with the oxygen of the air and forms ozone. There is great probability that in the simoom of the desert there is a large accumulation of ozone. Large quantities of electricity are reflected from the surface of the sand every twelve hours of sunshine; and it being known that electricity forms a combination with oxygen, there should be no difficulty in admitting that in the simoom there is a great concentration of ozone. The effect on the living tissues demonstrates that, like ozone, the simoom has a powerfully decomposing influence. Travellers in the desert, who are not prepared to take the best means for shunning its impressions, generally suffer severely from it. The camels trained to the peculiarities of the desert, when they anticipate its approach instinctively bury their heads in the sand. The barrenness of the desert may be perpetuated by the decomposing activity of this body. Being plentifully diffused in the air over the barren waste, both on its margins and in its centre, every particle of vegetable matter, which in a storm might be blown over to it from a fertile district, will be immediately decomposed, there being besides no moisture either to carry off the redundant ozone or to water the thirsty soil. Ozone in the air seems to have no connexion with the cause of cholera, except in so far as it indicates the electric condition of the air, or probably more correctly the amount of radiation from the earth. Radiation from the earth is, as already stated, the principal source of heat to the air, and is always going on at a temperature above the freezing point. It continues whether the earth be wet or dry. When the radiation of electricity takes place from a wet surface, it rises in combination with the moisture and accumulates in the clouds, leaving the soil in a negative condition. When the soil becomes thoroughly dry, the radiation still continues; but the dry air being a bad conductor prevents the diffusion of the free electricity, which, finding no conductor, is arrested by the oxygen, the only object with which it can form a union: and hence the ozone. The chief value of our knowledge of the presence of ozone in the air, is, that to a certain extent it is an evidence of the electro-positive condition of the locality over which it is found. So long as this element is present in abundance, there will be little chance of pestilential disease, as there cannot be the abstracting influence of a low condition of electric tension so favourable to the development of disease.

CONCLUDING OBSERVATIONS.

We have evidently still much to learn on the subject of electricity: as to its operation in every department of nature. Much more might have been gained both for philosophy and practical purposes, if inquirers into electrical science had searched after the general workings of this agency in the animal and vegetable kingdoms, instead of attempting to divide what is incapable of division—to demonstrate what cannot be demonstrated. Had this course been followed, those most distinguished for their labours in this department of science, might not have found it necessary to acknowledge their ignorance of the essential nature of electricity.

That portion of electricity in combination with the primary constituents of matter, and which was first discovered by Galvani, is not encumbered with the distinction of positive and negative, though virtually the same as the free electricity which passes from the clouds to the earth, or is made evident by friction with non-conducting substances. Free and bond are good distinctions of electricity, as one form is bound up with the primary constituents of all bodies, and the other radiates from one body to another.

It will be readily acknowledged, that the entertaining of correct views as to the remote cause of disease is a desirable object. The profession and society at large are both interested in a satisfactory settlement of this question. Because of the uncertain grounds on which conclusions have been made, the profession is divided into parties holding different opinions; and neither party being able to demonstrate by facts or philosophy the correctness of its views, both frequently become lost in the wilderness of conjecture, and encounter insurmountable difficulties, which can only be contemplated with discouragement and disappointment. It is of importance, too, that the profession appear before the public with a larger amount of principle founded on true philosophy, and a smaller amount of hypothesis founded on mere opinion. The public also is greatly interested in the manner in which this question is dealt with. Because of a belief in contagion when fever and pestilence prevail, alarms and apprehensions arise in the minds of many, causing so much mental disturbance as to react on the vital functions, and seriously mar the integrity of their operations, the corporeal derangements being in proportion to their fears. According to the multiplication of such cases will be the prevalence of febrile and pestilential disease. It is not individuals only, or even a small number of the ordinary members of a community, that are alarmed, but the civic authorities also, both in provincial towns and metropolitan cities. When their fears are great enough to excite them to action, they commence a search after all the nuisances which usually abound in alleys, closes, and back courts, and all manner of cleansing and fumigation is instituted forthwith. All this is done without in any measure arresting the progress of the fell destroyer; for notwithstanding the washing, deodorising, and fumigation, the complaint continues unabated. The most effective measures for arresting the progress of pestilential disease, are, as formerly mentioned, proper nourishment and clothing—the former to provide for the supply of nervous power, the latter to prevent its escape after being eliminated—dry and comfortable houses, and the avoidance of all kinds of dissipation and of exposure to the damp earth and air which usually prevail at times of pestilential disease. Dissipation wastes the vital energies, and its votaries are the earliest victims of pestilence in all its forms.

The sewage of the large city of London continually pouring into the Thames, causes that useful stream to be regarded with jealousy as the possible source of present and prospective evil. It is thus regarded only during the warm weather of summer, when its waters are most murky, and the air for a short distance above the stream is impregnated with odoriferous exhalations. When it is considered that in the very dwellings of many of the poor there is a constantly bad odour and a close vitiated atmosphere, to which the inmates are exposed for hours together, without apparent injury, why ought fears to be entertained in the open air of disease arising from the much less offensive and largely diluted odour of the river? The ashes of our forefathers, which have slept unsuspected and unquestioned for generations, are now suspected as being mischievous to the living; and though no proposal has been made to disturb their remains, yet objections are raised to allowing the future dead to be laid beside those with whom, while alive, they had walked in company; thus depriving the dying of what may be a last consolation: and all on the mere suspicion that the decomposing remains of the dead poison the air inhaled by the living.

If these principles are accepted as true, another question of public interest will obtain solution, viz., Are the quarantine laws required? There is unrestricted communication between this country and her West Indian colonies, where yellow fever often rages, yet we never hear of a case of this disease within our shores. According to the principles here advocated, it would scarcely be possible for this disease to be produced in this country, simply because there is neither the great and sudden wetness, the intense heat, nor the rapid evaporation, all which are essential for its production. It has been already shown that the very town in which this disease rages, can be visited during the day with perfect safety, it being only at night that danger exists; this danger, however, arising from a cause very different from infection. The operation of these laws is not much felt in this country, but it is experienced in those countries where pestilence periodically rages. In some of the colonial possessions of this country, these laws are actively enforced.

In the United States of America, yellow fever sometimes prevails on the coast and in the Southern States. It occasionally appears at New York also, but to a much less extent now than formerly, because the provisions necessary for its development are fewer than they were. In consequence of the dread of infection, hospitals were established for the reception of those affected with yellow fever, and of those also suspected to have it. One of these hospitals caused so much fear of infection in the people near whose habitations it was situated, that they forcibly removed the patients and set fire to the building. Public feeling being so much excited by the enforcing of laws the necessity of which has long been questioned by intelligent medical authority, why nurse the impression that pestilential disease is imported and then communicated by contact, since it has been demonstrated, at least to our mind, that this disease is produced by an agency connected with the soil? When people are so much absorbed with the idea that a disease is infectious, their whole efforts are employed to widen the distance between themselves and the diseased, while they are careless about being exposed to the endemic influences which are the true cause of the disease. In pursuing a phantom, they allow the offending agent to operate on them unmolested. If, in place of avoiding the unfortunate victims of disease, they avoided every moral and physical excess and every cause of electric abstraction which might lessen their nervous power, then, though careless of infection and of contact with a person in disease, they might altogether escape being attacked.

The fear of infection existing in the public mind is a consequence of the previously expressed belief of medical men in infection. To dispossess the people of their fears regarding what are reckoned infectious diseases, medical men should first get satisfied about what is really the remote cause of disease, and then enlighten the people. The author flatters himself that the present inquiry is in the direction to find out the truth; and should efforts thus directed be ultimately successful, a better basis will be formed on which to make more satisfactory arrangements, either enacting or repealing laws as to the best means for preserving health. Fears and perturbation of mind are not so much found in the neighbourhood of marshes, because the people often become reconciled to an infirm state of health, almost inseparable from such a position. In such circumstances, alarm would be salutary, were the people thereby stimulated to improve their position; and if, in their efforts to do this, they could not remove the mischievous agency by draining the marsh, it would be wise to leave the locality and select another. If this be impossible, let them take the means of insulation indicated in another part of this treatise. By attending to such indications, emigrants, on entering a new country, would know how to adopt a healthful position for their residence by avoiding all damp situations, as the vicinity of marshes, and by choosing high situations, and especially the summit of the elevation. In all countries within the torrid zone, it is important to have places of abode as much elevated as possible, and the ground around them so thoroughly drained that all the water falling during the rainy season will be carried off as soon as possible. The under-floors of the houses ought to be left unoccupied. People in many places in India, without reference to principles of this nature, but guided by intelligent observation of the phenomena which pass before them, have discovered that a high and dry situation is most conducive to health, and have consequently chosen such places for the sites of their dwellings. From these principles it is obvious that armies having a choice should never encamp on the banks of rivers. When this is unavoidable, they should always choose the highest and driest situation in their power. It would be very important for the health of the soldier, if means could be adopted to make him avoid lying on the ground; but if this be unavoidable, he might be provided with an oil-cloth to lay upon the ground under his blanket. This is impermeable to moisture, and the oil would also serve as a valuable non-conducting body.

RECAPITULATION.

In the foregoing work the author has endeavoured to establish the following propositions:—

That nervous power can be substituted by electricity, to produce not merely simple muscular action, but also the more vital and internal operations.

That the nervous system necessarily depends on the ingesta for the material of which it is composed.

That it is shown whence are procured the supply and the source of the power by which nervous action is produced.

That diseased action is produced by an abstraction of nervous power and consequent derangement of the corporeal operations.

That cholera prevails in all countries, but is most frequent and virulent in countries within the torrid zone. That it arises from a low state of electric tension, produced either by speedy evaporation or those occult influences which are the results, sometimes of volcanic action, sometimes of deviations of terrestrial currents. That this low state of electric tension causes abstraction of nervous power, and produces enervation of the capillary system and inverted action of the bowels.

That yellow fever is peculiar to those countries which have a high temperature—where there are successively great drought, heavy rains, and speedy evaporation, producing a low electric tension. That the negative state of the soil thus produced, abstracts from the human body nervous power, both speedily and copiously, and deprives the secreting, excreting, and other vital organs of that which is indispensable to their healthy and efficient action. That this is followed by vitiation of the blood, clogging up, and bursting of the capillaries, and breaking up of some of the internal organs.

That plague has its origin from the same instrumentality, operating, however, less powerfully. That the heat is less intense, and the evaporation less copious, in the localities which are visited by this pestilence. That in those countries in which this disease is endemic, the variations of electric tension are neither so sudden nor so great as in those countries where yellow fever prevails. That in plague, the slower but more continuous evaporation causes a more slow and gradual abstraction of nervous power from the animal body. That, as in yellow fever, so in plague the blood becomes vitiated —but less hurriedly—and its altered consistence renders its progress through the capillaries difficult; causing their rupture where weakest, giving rise to internal lesions and external ulcerations.

That intermittent fever is produced by a still smaller amount of nervous abstraction. That it has the same origin as the previously mentioned disease. That the localities in which this disease is endemic are marshy, or in circumstances analogous, and maintain a slower and more persisting evaporation, and a proportionally slow abstraction of nervous power.

That the views here taken of the pathology of pestilential diseases satisfactorily account for the difficulty of treating them, especially when they are once established.

That the treatment, to be successful, ought to be commenced at the time of the earliest manifestation.

That those living in pestilential regions should have their habitations dry, and well elevated, and their beds insulated by good non-conductors, and should be as little out of doors as possible during the absence of sunshine, unless the soil be thoroughly dry.

That fever on board ship is caused by continuous evaporation, and consequent low state of electric tension. That on this account they ought to be kept as dry as possible, and with no water in the hold, especially in hot climates. That care ought to be exercised not to take a moist cargo on board. That in an unhealthy locality the seamen ought never to be on shore at night.

That a high situation is favourable, and a low one unfavourable to health, arises from the more elevated being drier, and having less provision for evaporation.

That authors have long considered that electricity had some connexion with the production of disease, but never have given definite ideas of its *modus operandi*.

That in proportion to the amount of ozone found in the air, so is the locality in an electro-positive condition.

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